



Impact of Indian sponsored projects on research performance

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Received: 03 December 2021; revised: 31 May 2022; accepted: 05 June 2022

Fourteen Indian research funding agencies have been studied to know their impact on research in India. Natural Language Processing (NLP) was used to segregate and identify the funding acknowledgment from data available in Scopus. SciVal, an analytical tool was used to analyze the data. Tableau software was used to visualize the analyzed data. The impact of 10 years of funding by the 14 funding agencies reveals the consistency of publication output. The number of funded publications addressing the 16 Sustainable Development Goals (SDGs) is very few. The study result indicates the need for a policy change among funding sponsors while considering the high priority areas. It highlights the necessity of considering 16 SDG while funding. The outcome of this study can be used for policy discussions in the promotion of Industry-Institutional collaborative funding and research and policy changes in funding the high priority areas of 16 SDGs in promoting collaborative research and infrastructure.

Keywords: Research funding, Bibliometric analysis, Trend analysis, Universities

Introduction

The sustainability, health and well-being, and societal progress depend on the nation's investment in scientific research. For enriching a nation's scientific knowledge, competitiveness, and contributions, research funding plays a prominent role¹. Researchers, policymakers, and funders have recognized the importance of funding and scientific research in providing the foundations for innovative research². This realization has been complemented by an increasing amount of government funding allocation in various areas of societal importance.

Research fund allows researchers to secure finance for research facilities and manpower, and provide assistance to other research needs, potentially leading to more autonomy and flexibility. R&D investments lead to greater scientific output and, lead to a better economic and societal performance³. Continuous investments in research and development are considered a key element of success⁴. Funding systems differ across the globe and many countries across the globe invest differently in research.

More than 4% of South Korea's GDP is spent on research. Many of the developing countries spend,

less than 1% of their GDPs⁵. The United States spent \$456.1 billion on research and development in the year 2013⁶. Switzerland spent CHF 22 billion on research and development in the year 2015, which accounts for 3.4% of the country's GDP. In India, the gross expenditure on R&D (GERD) in India has been consistently increasing over the years and has nearly tripled from Rs. 39,437.77 crore in 2007-08 to Rs. 1,13,825.03 crore in 2017-18. India's per capita R&D expenditure has increased to PPP (Purchasing power parity) \$ 47.2 in 2017-18 from PPP \$ 29.2 in 2007-08. India spent 0.7% of its GDP on R&D in 2017-18. The report from the Department of Science and Technology published in the year 2020 also talks about similar data about the BRICS countries.⁷

The process of funding for a research project is quite lengthy and not all researchers who apply for funds are successful in receiving them. Funding agencies require information about researchers' background, facilities used, equipment needed, time involved, and overall outcome or success rate of the research. The grantee is required to write a proposal to funding agencies and the grantor is required to choose the best proposal. The process of writing and

accepting a grant is difficult for both grantee and grantor because individual grantees would want to apply for research support in which they have the best chances and grantors must choose research that fits their scientific principles. There are administration offices in most universities, which act as a bridge and ease the interaction between funding agencies and researchers.

Funding agencies from foreign countries also provide research grants to Indian researchers either individually or in the form of collaborations with Indian funding agencies (Indo-US, Indo-German, Indo-Russian, Indo-Australian, etc.).

National Education Policy 2020, which was approved by the Union Cabinet of India on 29 July 2020, outlines the vision of India's new education system⁸. A new National Research Foundation (NRF) to take care of funding, mentoring, and building the quality of research in India has been announced. It aims to fund researchers working across various streams in India.⁹ To bring non-science disciplines of research within its bounds, the NRF will fund research projects across four major disciplines – Sciences; Technology; Social Sciences, and Arts and Humanities. NRF aims to resolve the lack of fund allocation, which has often been cited as one of the biggest reasons behind the poor performance of researchers in India.

This study aims to evaluate the funded research works quantitatively and qualitatively to know the impact of funding on research and society. This study provides an insight to the funders in India and abroad to rethink the need for databases that highlight the value added by them through funding, the latest research areas, and what it has contributed to society.

Review of literature

The reasons for the insufficient performance of quality research in India are lack of skilled faculty, understaffed colleges, and so on¹⁰. A limiting step in the government funding agencies is the lengthy, not so transparent process, lots of paperwork, and too much time taken between submission of a research proposal to the approval of grant¹⁰. If innovations in basic science must continue at the same speed as they did in previous decades, a solid strategy for funding with timely evaluation is required¹¹.

Government funding agencies should and will remain the main source of funding, but one must also investigate the availability of private funding options

too. If not, investigators would lose opportunities at any career stage¹². A detailed budget with justification, summarising costs of every item, and an explanation as to why each item in the budget is necessary to carry out research are the details that funding agencies look at in a proposal. The researchers should adjust the budgeted items for inflation within the bounds of the funding agencies¹³.

It was observed that research papers emanating from funded research had a higher quality than that of non-funded ones¹⁴. Research can be quantified with the help of bibliometric measures. Some studies highlight the importance of analyzing the public research bodies and as a result, they could find out the top institutions which required the funding¹⁵.

The impact of funding may affect performance through networking and increase the processes of collaboration, international exposure, and other communications resulting in outstanding research outcomes. Funding will also bring recognition, excellence, publication contribution, etc. that can be considered a performance measure in itself, and that it may bring a positive impact on research, and the performance of the institutions itself¹⁶. Comparing the funding background of five European countries (Germany, Denmark, Great Britain, France, and the Netherlands), found that the national research performance increased due to funded publications, and the impact of papers that comes out of funded research programs by foreign organizations, on an average, is higher than those of domestic ones¹⁷. The cut in government funding led researchers to collaborate with firms and external institutions for funds¹⁸.

Acknowledgments given in a research paper are recorded in the Web of Science (WoS) database only if the publication contains funding information. It is not possible to analyze the funding acknowledgments data of publications written in languages other than English¹⁹. Funded publications in the areas of the 16 SDGs are important. The impact of funding on these special areas is gaining importance in the present time and the future funding distribution can be strategized by looking into the outcome of funded research²⁰.

A funded research study has been carried out on EC Framework Programmes and the effect of geographical diversity in collaborative projects. The study explains that projects with a wider diversity of research partners are more likely to deliver innovations with greater potential. The work explains that these projects have more organizational diversity,

offer greater learning opportunities, and have access to a broader network of knowledge sources and competencies²¹.

Some studies investigated the Canadian support structure at federal level funding that aims to support the commercialization of the publically funded project. The program aims to induce structural reforms within the university sector to improve the institutional capabilities to facilitate commercialization projects and the support it is providing to specific commercialization projects. The study reveals the support of the universities in the commercialization of university innovation. Universities either provide resources for use in commercialization projects either directly or through the development of professional expertise²².

Evidence-based research evaluation is gaining importance to support various objectives for institutional and researcher analysis and healthy grant application review. There are various methodological measurements and bibliometric assessment of performance. A pattern of funding success data study on Canada's Natural Sciences and Engineering Research Council (NSERC) individual research grants (Discovery Grant) program (2011–2014) has expressed the importance of subject-specific review and the importance of avoiding bias in the allocation of research funding. They have emphasized the importance of bibliometric measures and subject-specific reviews in restoring confidence in the objectivity and fairness of science funding decisions²³.

From the start of 2020, research sponsors have generously funded COVID-19 research and we could expect a spurt in publications in this area. The study in the societal infected area has turned to the production of research papers 1.2% daily, based on notes and short papers mainly open access that supports scientific advances and discoveries as described in the research paper. In comparison to the areas of previous importance in the related fields concerning respiratory disorders that are not guided by pandemic crisis, such as chronic obstructive pulmonary disease and lung cancer gain less importance in funding and research than the disease which causes the pandemic crisis. There are comparative studies done that explained the emergence of new research fields under conditions of societal crisis and the flow of research funding calls in these areas²⁴.

An analysis was done on the relationship between research funding and citations in the field of life science. The study results reveal that more than funded, there are un-funded articles in the field of life sciences. Their research reveals that funded documents receive more citations than un-funded papers in all research fields of life science²⁵. In a funding-citation relationship analysis, it is explained that computer science journals published more funded papers than unfunded papers. Medicine journals published equally funded and unfunded documents, and finally, economics journals published more unfunded than funded papers²⁶.

The present study highlights the impact of Indian sponsored projects on the research performance. Fourteen Indian funding agencies that have a record of regularly funding for the last 10 years have been considered for this study. It aims to identify the major funding agencies in India and their impact on research for building a sustainable society. The data range considered for the study was 10 years, and the impact of funding and its different quality metrics are analyzed in detail. The impact of 10 years of funding by the 14 agencies reveals the consistency of published articles each year with an increase in number and a promising number of publications addressing the area of 16 Sustainable Development Goals (SDGs).

Sample and data measures of variables

Relevant data required for this analysis has been collected from Scopus and SciVal. Scopus has a broad coverage of all subject areas. Therefore, we have used the Scopus to get the relevant data for the present study. Scopus gives unparalleled and continuous access to critical research output published across the globe. Scopus provides the platform, tools, and insights to connect academia, government, and corporations. SciVal is an analytical tool that facilitates measuring metrics from Scopus.

Since the objective of the study is to find the impact of funded publications, the data on funding outcomes as publications from the year 2010 to 2019 was collected from Scopus. We searched with the funding agency name and its known variants. The data was exported to SciVal analytical tool for further analysis.

It was observed that nearly 130 funding agencies are there which have the highest number of contributions in terms of publications from India

indexed in Scopus during the said period. After pre-processing the data, the top 40 funding agencies with the highest funding opportunities were chosen for analysis. We have used inclusion-exclusion criteria (consistency) which again limited the funding sponsor number to 14. Table 1 gives the list of top agencies.

Analysis

Regression analysis was used to examine the trend of publication in the coming five years and it was

Table 1 — Funding agencies and abbreviations

Sl. no.	Funding Sponsors (sample for the study)	Abbreviations
1	Department of Biotechnology	DBT
2	University Grants Commission	UGC
3	Council of Scientific and Industrial Research	CSIR
4	Board of Research in Nuclear Sciences	BRNS
5	Indian Council of Agricultural Research	ICAR
6	Department of Science and Technology	DST
7	Ministry of New and Renewable Energy	MNRE
8	Ministry of Earth Sciences	MEO
9	Ministry of Human Resource Development (Presently, Ministry of Education)	MHRD
10	Ministry of Communication and Information Technology	MCIT
11	Ministry of Coal	MoC
12	Department of Science and Industrial Research	DSIR
13	Ministry of Electronics and Information Technology	MeitY
14	National Board for Higher Mathematics	NBHM

exported to SciVal to get a detailed report on research metrics. SciVal give a detailed report based on quantity and quality parameters. The analyzed data was exported from SciVal to get a visual representation.

Tableau is a data visualization tool, which enables us to visualize and analyze data quickly and effectively. It is useful and a flexible tool for connecting and analyzing all types of data. It is a vital tool for data scientists to visualize and gain insights into their data. Data from sources like Excel, SQL servers, and cloud-based data repositories are compatible with Tableau. Linear regression analysis is done to see the predictive trend for the coming five years. Its user-friendly interface enables us to use its various features with ease and speed.

Funding agencies and impact study of funded publications

On examination of data through funding acknowledgment analysis, the top 10 funding agencies in terms of the number of publications were found to be the Council of Scientific and Industrial Research (CSIR), Department of Science and Technology (DST), Department of Science and Industrial Research (DSIR), Department of Biotechnology (DBT), University Grants Commission (UGC), Ministry of Coal, Ministry of New and Renewable Energy, Board of Research in Nuclear Sciences, etc. (Figure 1).

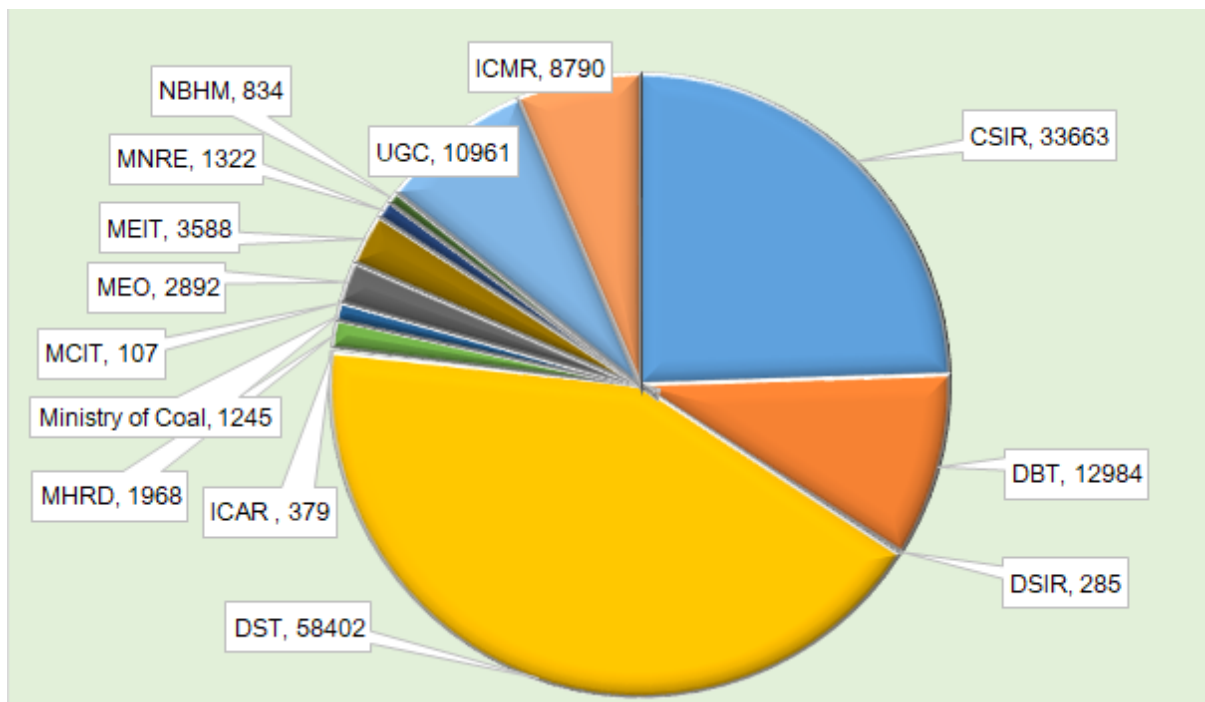


Fig. 1 — The top 14 funding agencies in terms of the number of publications

The impact study of research helps to focus on the purpose of research instead of just the research process. Focusing on research impact helps us to ensure that we get the best possible returns from the investment that we, as a society, make in research.

Publication trend analysis

With the simple predictive analysis, we can always visualize the trend of future growth keeping a few previous years’ data. The linear regression model we have used here to predict the future trend and the R-squared value for each funding sponsor’s predictive analysis is almost near 0.99 which is an acceptable trend. From the trend curves presented, it is obvious that the research outputs follow the research funding in emerging research areas.

Figure 2 shows the publications that acknowledged the DST and the ICMR for the period 2010 to 19 obtained from the Scopus database. Both the funding

sponsors are showing an increase in publication trends during the 10 years. Even though DST showed slow growth in publications till 2015 but we could see a sudden change in publications with rapid growth from 2015 to 2019. DST is the oldest and most well-established government funding sponsor in India. ICMR is also an established govt. agency in the field of medical sciences. The necessity of trend analysis here is to predict the expected minimum and maximum publication according to the last 10 years’ performance. The linear regression analysis and the prediction model clearly show the trend in the growth and the tested value with R² value for both funding sponsors also shows a value near 0.99% which is a good predictive trend. The progressive growth credited to DST shows the value of publication in research. All the funded projects are given importance to publications and the necessity of acknowledging these funding sponsors is well known to the

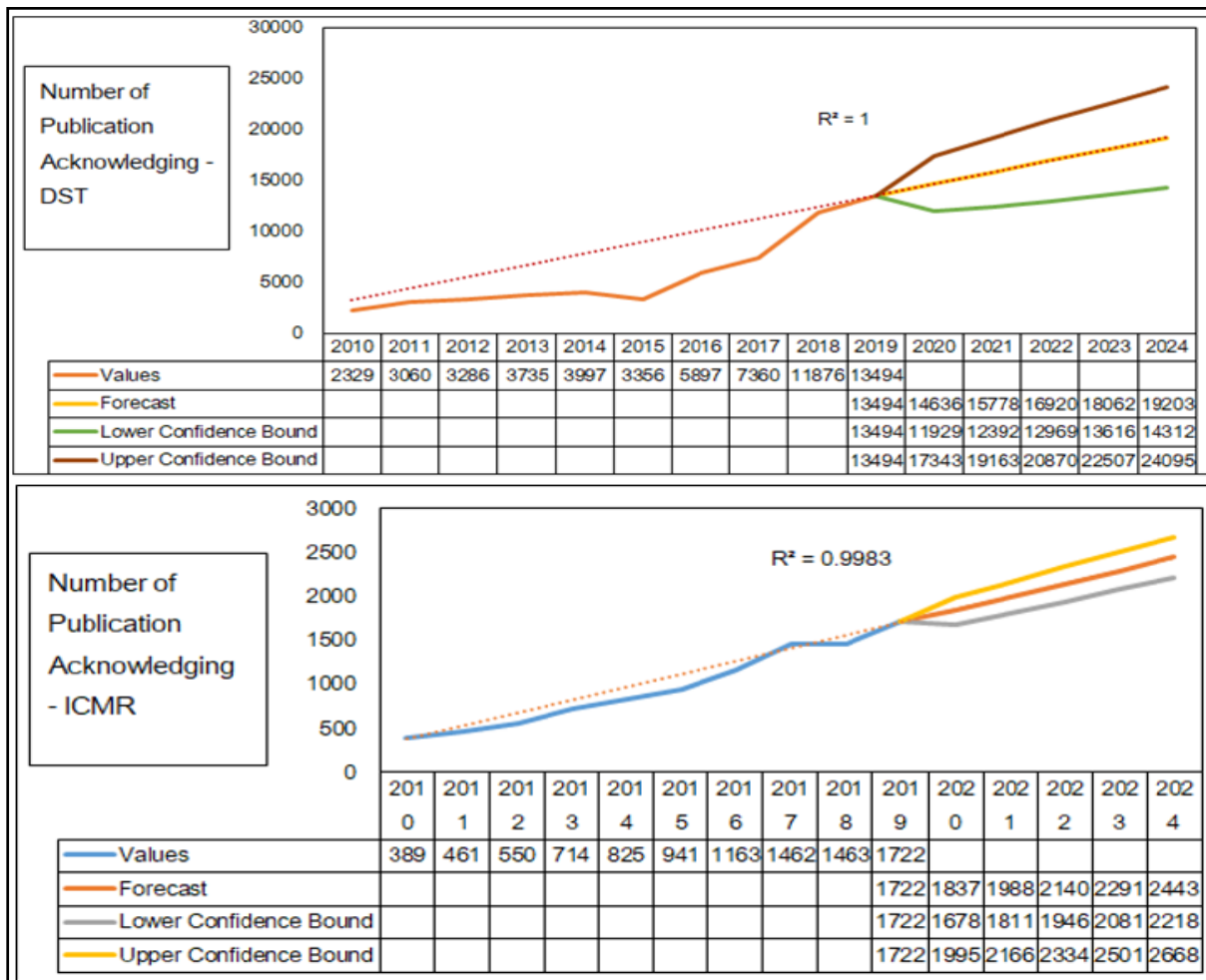


Fig. 2 — Publication trend prediction of DST and CSIR for the period 2010-2019

researchers and funding sponsors because the publications are the only immediate parameter to convince the progress of any funded projects.

The acknowledgment analysis result illustrates the exponential trend in the publications from India and the same applies to funded research also. When we look at the publications for the past 10 years we could see a promising growth trend. Figure 3 shows the publications that acknowledged DBT and CSIR for the period from 2010 to 2019 which are collected from the Scopus database. Both the funding sponsors are showing an increasing trend in the publication number during the 10 years. Even though there is a slight drop in the publication number for the year 2015 for both funding agencies we could see it reverse back with a hit in publication number in the coming years. The necessity of trend analysis here is to predict the expected minimum and maximum publication according to the last 10 years' performance. In the growth analysis period, 2010 -

2019, the exponential trend line shows its well-fit position with an R^2 value of 0.99 for DBT and 0.97 for CSIR. The linear regression line expresses that the number of publications in the credit of DBT and CSIR is growing faster and faster over time.

The Council of Scientific & Industrial Research (CSIR) promotes, guides, and coordinates research in India to translate research investment into improvement in the quality of human life. The tremendous growth in the credit of CSIR shows the value of publication in interdisciplinary research. The growth trend in DBT shows an increase in publications in the area of biotechnology.

Under the Ministry of Education, many programs are initiated for the promotion and state-of-the-art deliberations of the research to the society with the aim of innovation, patenting, and technology transfer. The Ministry of Earth Sciences and Ministry of Ocean Development of India is responsible for the research and development of weather, climate, ocean, and

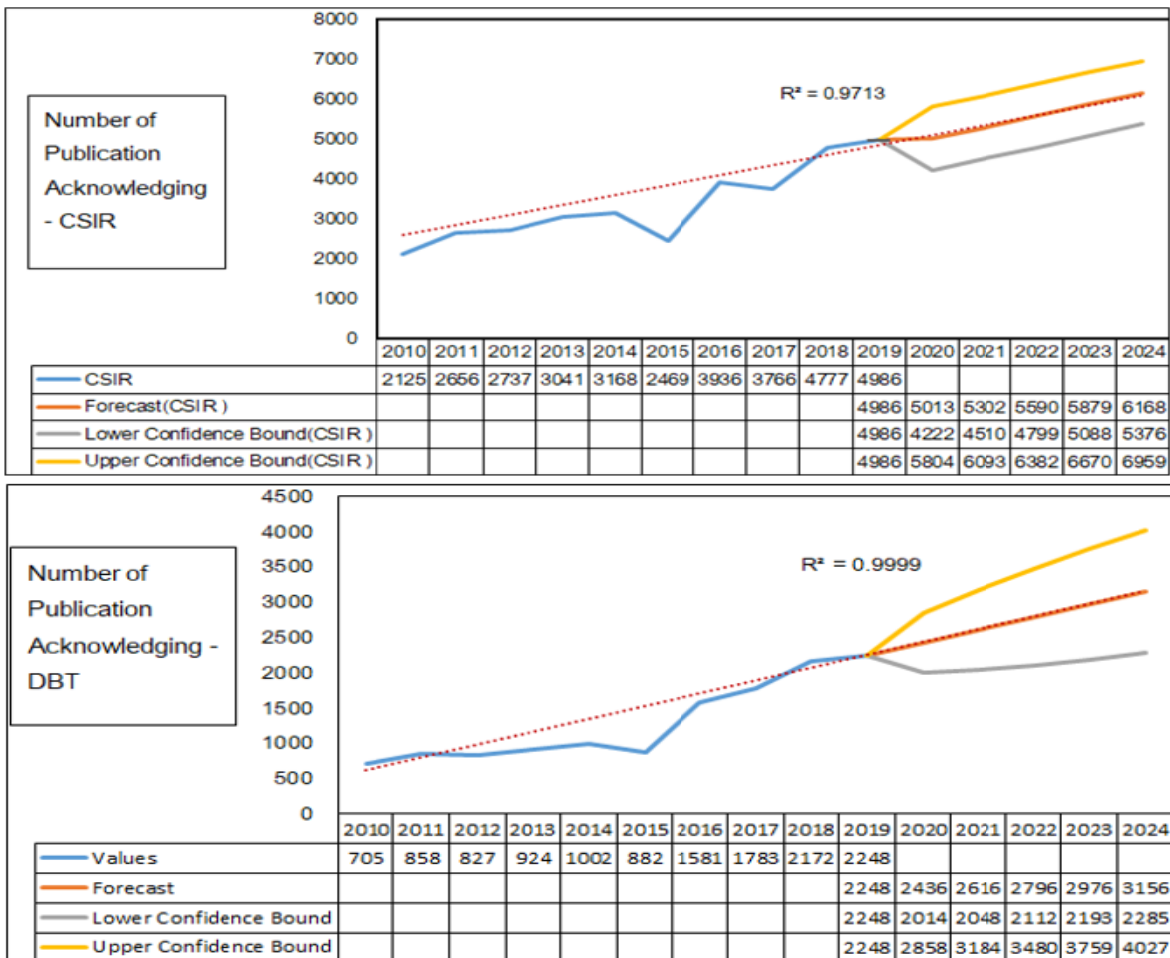


Fig. 3 — Publication trend prediction of DBT and CSIR for the period 2010-2019

coastal issues like natural hazards, marine living, non-living resources, etc. Both the funding sponsors have publications in their credit from 2010 to 2019 but the publication amount is very less when compared to other funding sponsors. Under the Ministry of Education, many programs are initiated for the promotion and state-of-the-art deliberations of the research to the society with the aim of innovation, patenting, and technology transfer. These funding sponsors are funding the very important and emerging areas of science and we can expect more exponential growth in this area in the coming future. In Figure 4, the linear trend lines for both the funding sponsors show very good growth in the future years with an R^2 value of 1 and it is a promising trend for both the funding sponsors.

In Figure 5, we could see that even after having a few publications in the credit, the trend line of UGC

and MeitY expresses the exponential growth in publications over the last 10 years. The R^2 value of 1 for MeitY and 0.98 for UGC are a clear indication that the publication trend is giving a promising future indicating the need to concentrate on funding these areas of research more in the coming years.

Information technology is the area that analyzes technology trends, identifies thrust areas, and leads the world through AI and ML technologies. Ministry of Electronics and Information Technology (MeitY) also promotes research by funding breakthrough research in the related subject areas in developing new technologies for the benefit of humanity.

Ministry of Coal funding agency has a good number of publications credited in their account from 2010 to 2019. Ministry of New and Renewable energy looks after all the aspects relating to New and Renewable Energy. Fund allocation and distribution

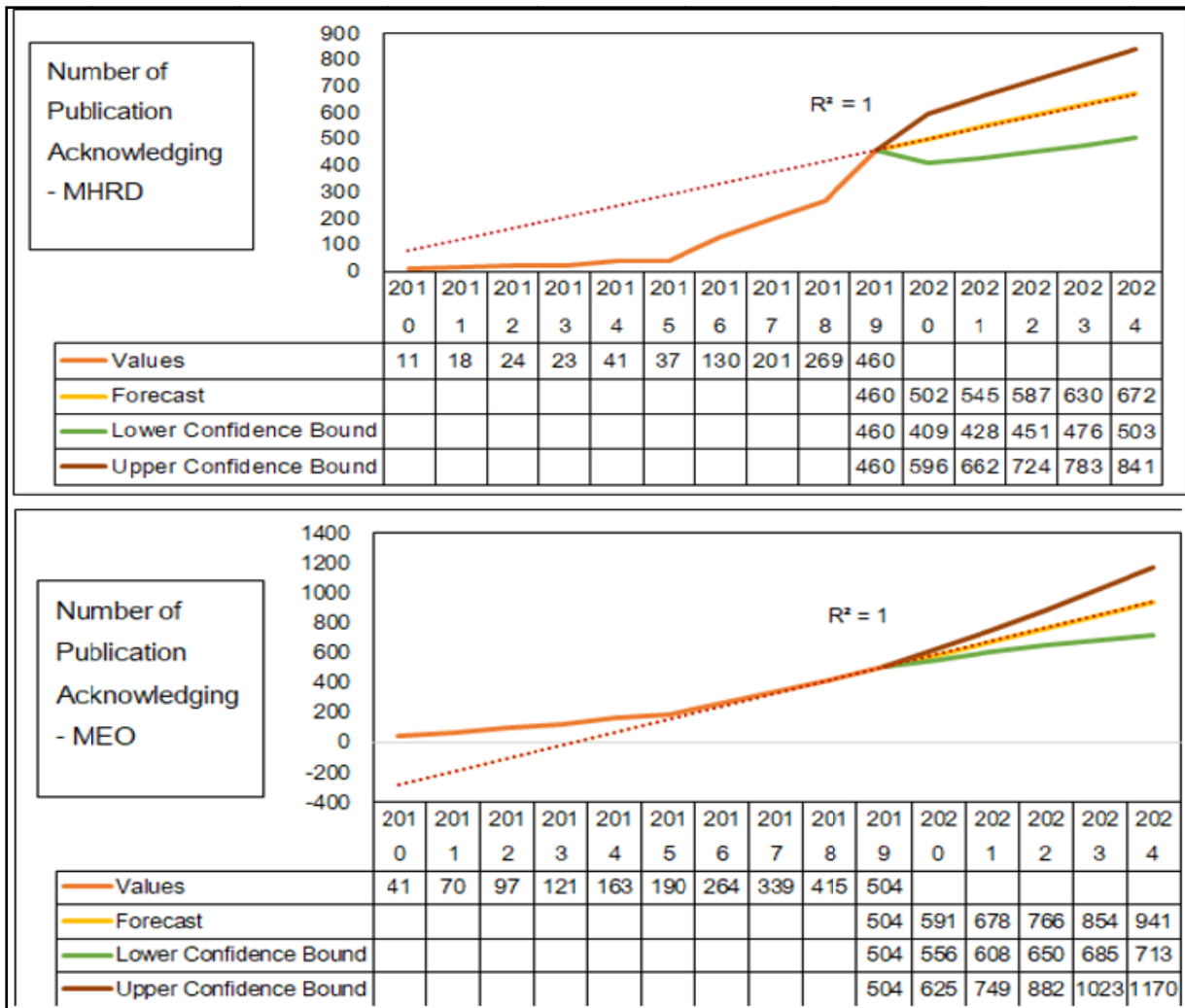


Fig. 4 — Publication trend prediction of MHRD and MEO for the period 2010-2019

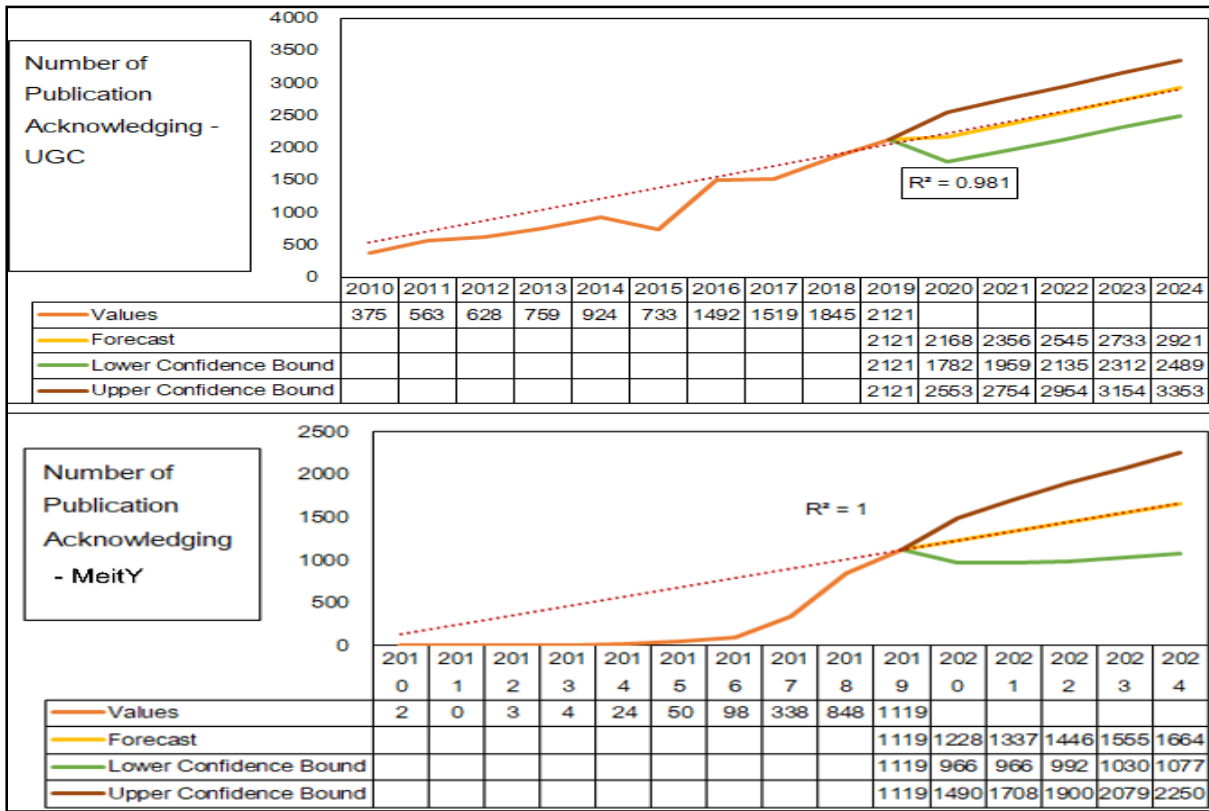


Fig. 5 — Publication trend prediction of UGC and MeitY for the period 2010-2019

on energy consumption, the production, distribution, and various aspects of energy-saving, green energy, etc., are among the many areas in which state of the art research is needed. Research proposals submitted by researchers in these areas will be peer-reviewed, and eligible themes and state-of-the-art research proposals will be selected for the award of research funds.

The research in the area of Coal focuses mainly on improving production and safety in coal mines. On the other side, the beneficiation, utilization, and protection of the environment. Institutions that do research in this area will submit proposals with the latest technological ideas, and those will be peer-reviewed. Funds will be allocated to implement those novel ideas. Significant funding and a large amount of dedicated research in this area started in the last five years. Figure 6 shows the publications that acknowledged MNRE and the Ministry of Coal during the period 2010 to 19. Both the funding sponsors are showing an increase in publication trends. Even though there are very few publications in their credit each year in comparison to the major funding agencies in India. In the growth analysis

period, 2010 -2019, the exponential trend line shows its well-fit position with an R^2 value of I for the Ministry of Coal and 0.97 for MNRE.

Total Publication on 16 SDGs VS Publications as an Outcome of Funded Project

Knowledge creation and research are essential for the growth and sustainability of a large and dynamic economy, the vigorous development of society, and the continuous effort of a country to reach higher peaks in all walks of life.

Due to the rapid development changes today, such as climate change, increasing population, expansion of digital markets, and development of Machine Learning and Artificial Intelligence, a robust research ecosystem is more important than ever. For this, a country must significantly expand the scope of research, create opportunities, come up with remarkable achievements in all disciplines, and genuinely allocate research funds to enrich these diversified fields. This study investigates the contribution of sponsored publications in developing societal important topics of 16 United Nations (UN) Sustainable Development Goals (SDGs). Although the SDGs are divided into 17 distinct

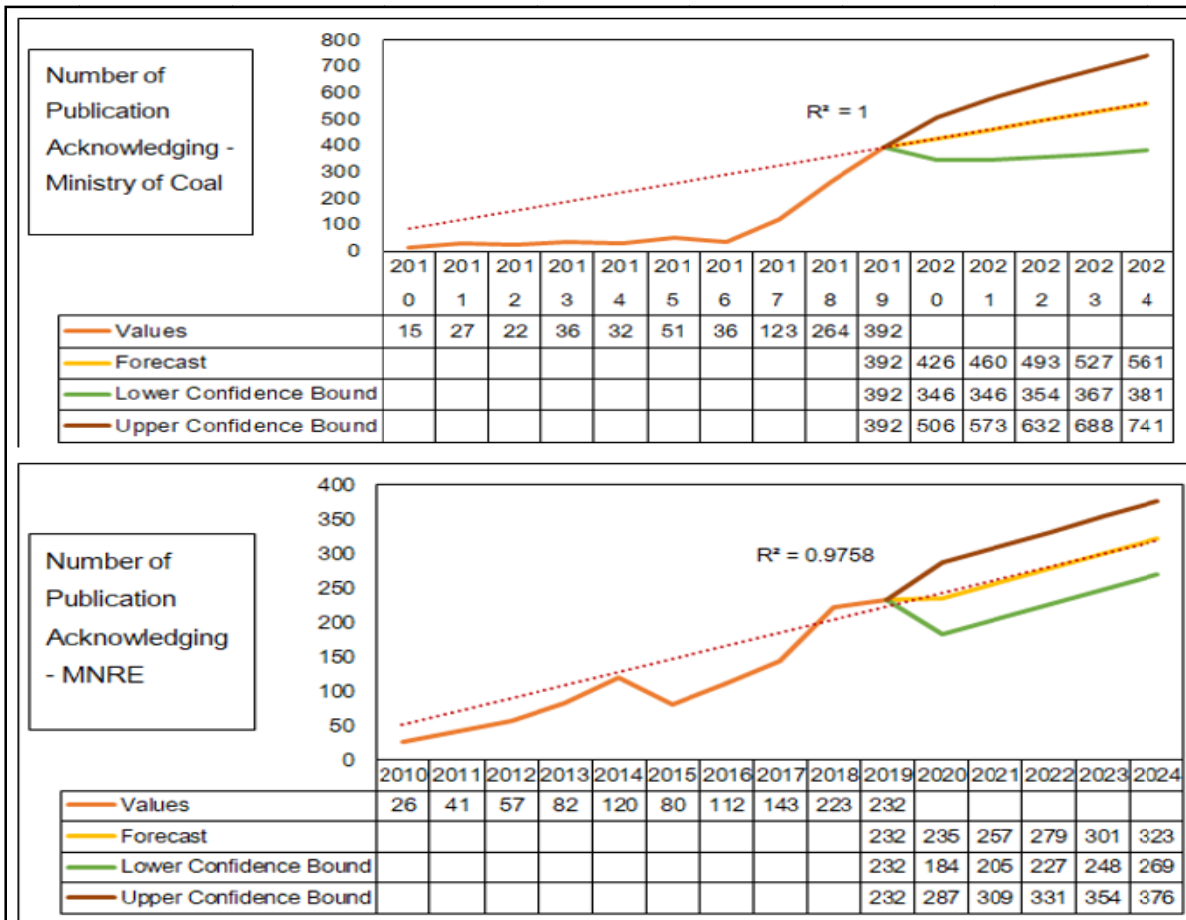


Fig. 6 — Publication trend prediction of MNRE and Ministry of Coal for the period 2010-2019

components, the objectives are inextricably linked, creating an indivisible structure aimed at achieving integrated sustainability from a structural perspective. On the one hand, achieving one objective or aim can aid in the achievement of other objectives. Goals and their associated targets are linked to shaping a complex web of interconnections. Comprehending the connections among the SDGs and their targets will aid in the identification of possible synergies and trade-offs. SDG research is mainly focussing on ending poverty, ending hunger, encouraging good health and well-being, providing quality education, promoting gender equality, providing clean water and sanitation, promoting affordable and clean energy, providing decent work and economic growth, addressing industry, innovation, and infrastructure, reducing inequalities, developing sustainable cities and communities, encouraging responsible consumption and production, taking action on climate change, promoting life below water, promoting life on land, working towards peace, justice, and

strong institutions, and creating partnerships to achieve SDG goals.²³

To achieve greater progress in the ambitious 16 SDGs the involvement of policymakers, and research fund sponsors is very important at all levels. This study and the quantification of research outcomes based on funded research are of importance in this context. To know the achievement all funding sponsors got in the progress of developing a sustainable society, hence it is very important to analyze and see the achievement of all SDGs. Figures 7 and 8 are visualizations of 16 SDGs' contributions to India for the past 10 years and the acknowledgment analysis of this data gave the research output of major funding sponsors. From the figures, we could see that SDG 3, SDG 5, SDG 6, SDG 11, SDG 12, SDG 13, and SDG 15 can claim that they have 10 to 14 percent of contributions. This analysis will give funding sponsors and policymakers to evaluate and release future funding in the areas of prime importance.

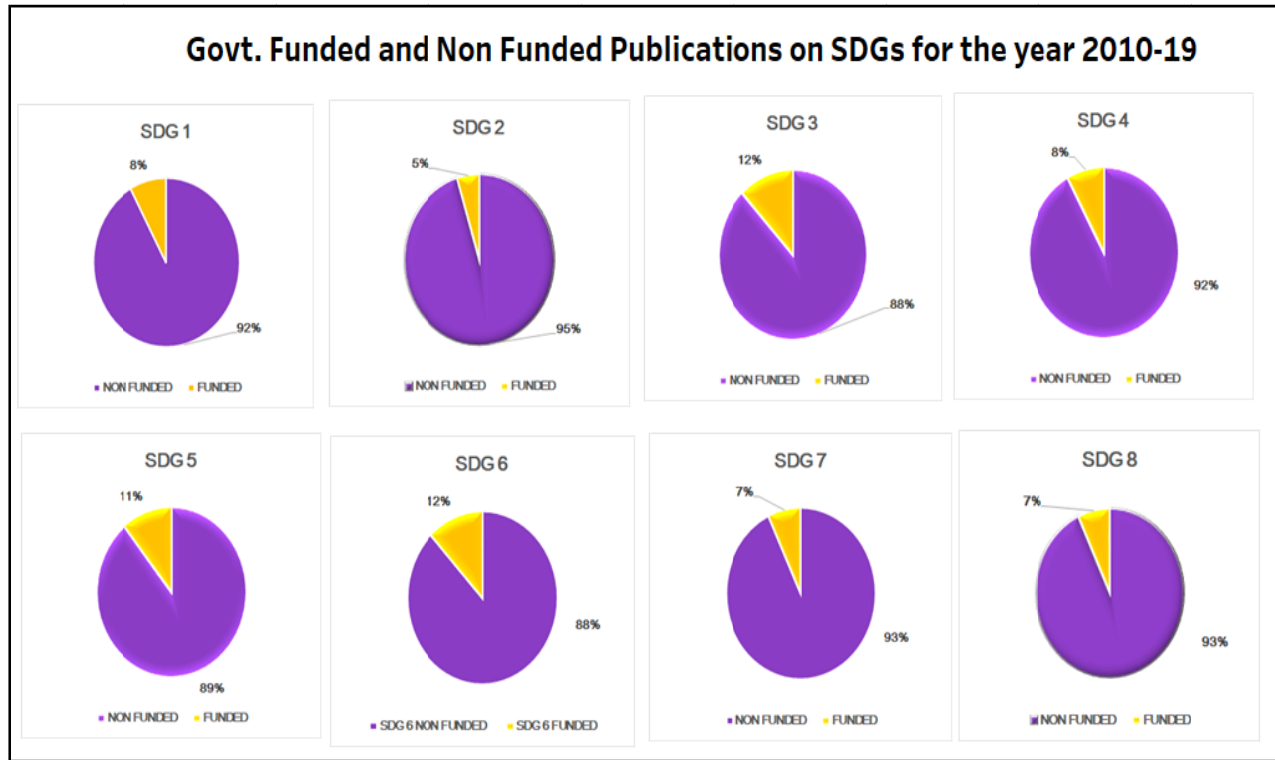


Fig. 7 — Publication contribution of govt. funded and non-funded publications on SDG1 to SDG 8 for the year 2010-19

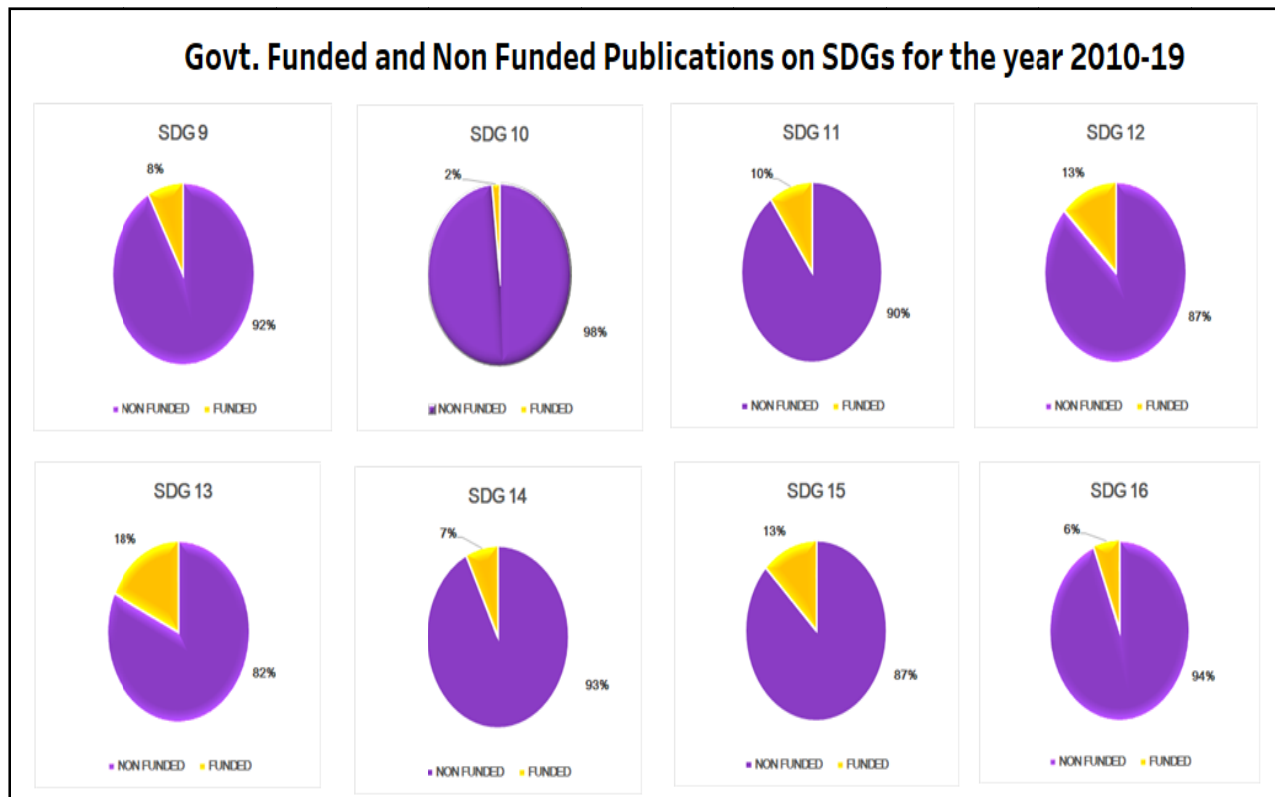


Fig. 8 — Publication contribution of govt. funded and non-funded publications on SDG 9 to SDG 16 for the year 2010-19

Bibliometrics Analysis of the Top 14 Govt. Funding Sponsors in India

The bibliometric study doesn't only see the collaborative and quantity of publications, it evaluates the impact of each publication given to society. Previously, bibliometric studies concentrate more on quantification, collaboration nodes, top authors, etc. here the study has been concentrating more on the impact of publication and its evaluation was done using various metrics.

Figures 9, 10, and 11 explain the outcome of the Indian govt. funded research publications for the 10 years duration (2010-19) with the help of various metrics. As far as publication number is concerned, DST scores the highest with 58402 followed by CSIR (33663), DBT (12984), UGC(10961), and BRNS (8790). Also, while analyzing the citation received for the last 10 years, these funding sponsors came on top positions. The cited publication is another important metric that provides among the many published research papers how many articles got cited in a span of time. It is very promising to see the cited publication data where 96% of UGC,

CSIR, and DBT publications are cited, followed by BRNS, ICAR, DST, MNRE, MEO, MHRD, etc. having 94% to 91% of publications are cited. The quality and importance of funded research output are easily explained from this metric. The publications that come out of each funding sponsor are cited by 150 -200 countries. This metric also talks about the worldwide acceptance and quality of research in India.

While analyzing the different types of collaboration and their impacts such as International, National, and Institutional, we could see that more than international collaboration, national and institutional collaborations are bringing publications. But there are more than ten thousand publications for DST which may be collaborative projects with foreign countries. To increase the economic and societal impact of research networks, it is very essential to know the organizational and geographic diversity of collaborating institutions and countries and their economic outcome.²² This kind of preliminary study is essential to increase the impact of publication incorporation with groups of people with different cultural backgrounds.

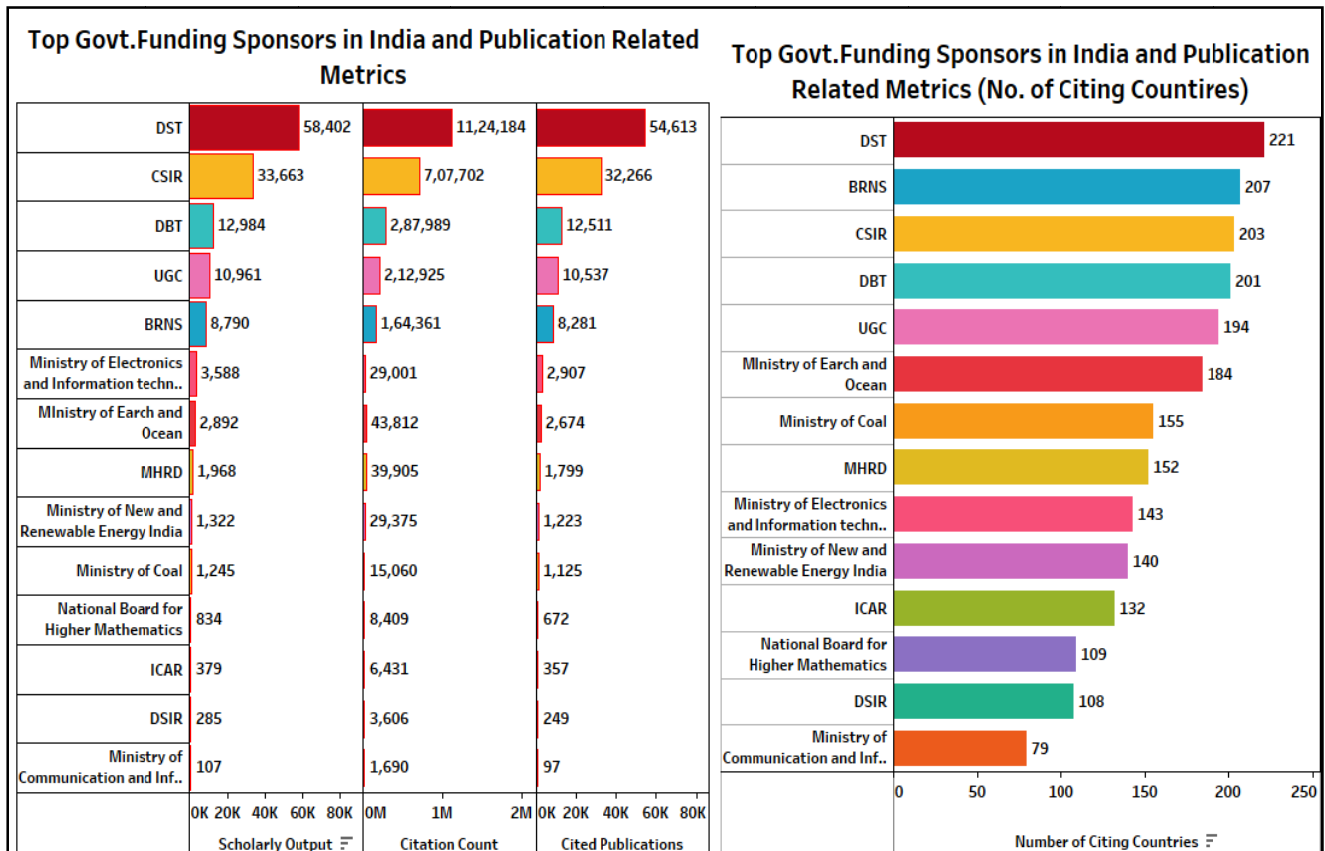


Fig. 9 — Output of funded project and important metrics

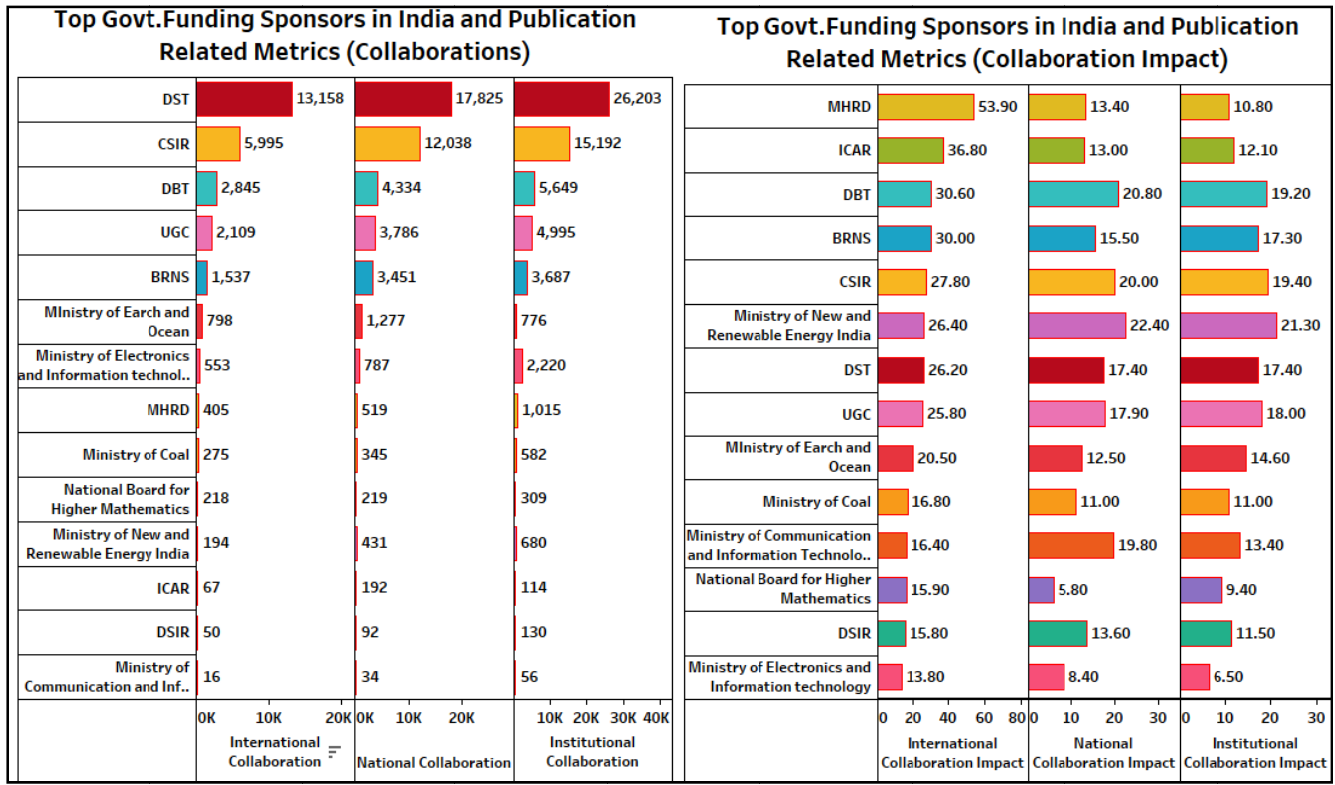


Fig. 10 — Output of funded project and important metrics

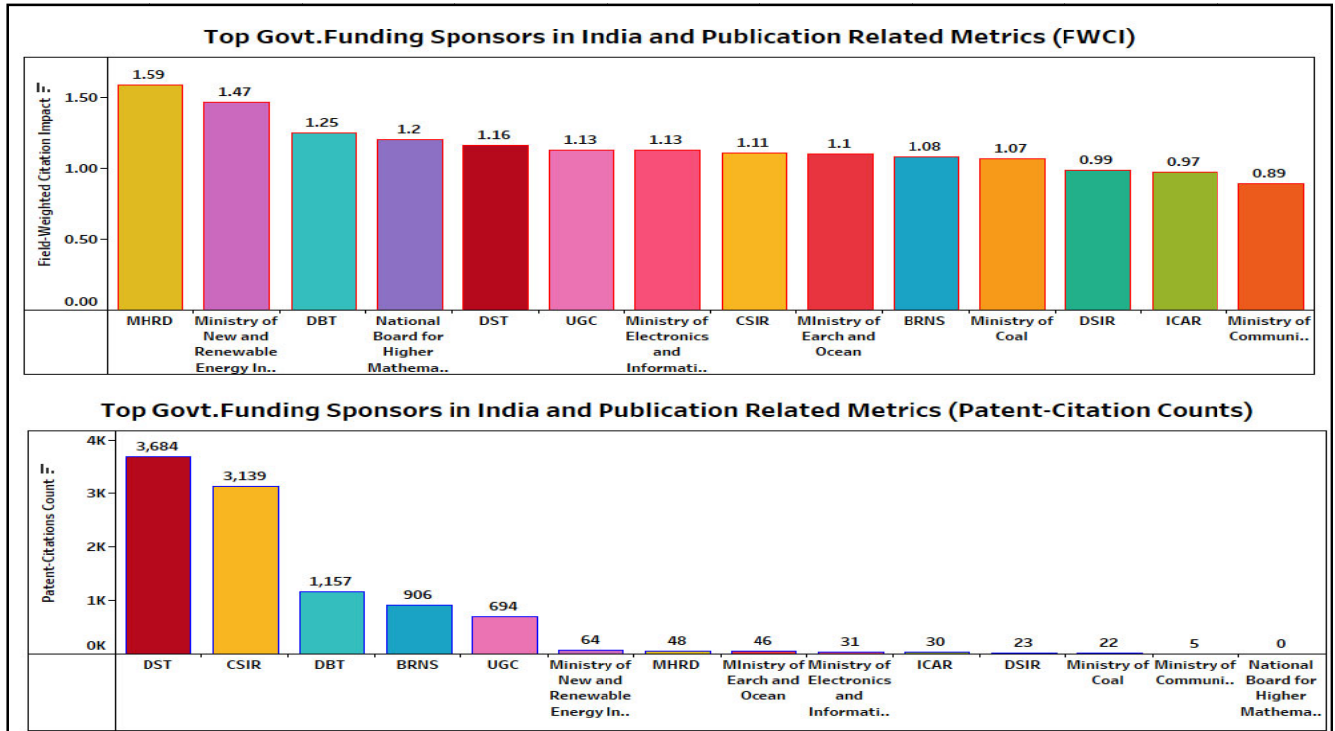


Fig. 11 — Output of funded project and important metrics

The highest number of publications came from institutional collaborations than others. When we analyze the data more deeply to the impact level we could see more impact coming from internationally funded publications. These results can be utilized for framing policy changes by funding sponsors by encouraging collaboration with foreign universities and funding bodies. Patent-citation count for each funding agency could be another metric that will help in formulating strategies and policies for the improvement of research. These metrics should be used for decision making, and policy formation and can be a way of understanding the necessity of patenting the ideas before publishing the work. Many initiatives are emerging at the university level and country level for the commercialization of research which leads to different policy changes, and legislative changes with high expectations, universities have also improved their policies to create incentives for researchers.

Conclusion and recommendations

The present research analysis is performed because of the lack of studies undertaken in India on the output and impact of funded research projects and sponsors. This study reveals three intriguing observations related to the outcome of funded research programs.

1. The funding sponsors who have the highest and lowest number of research outputs in their credit must caution the importance of acknowledging the funder in each publication.
2. The present study has enlightened the importance of 16 SDGs and the output of the funded research projects related to them. This study has highlighted the importance of evaluating the already released funding in these areas and can be used as a metric for formulating new policy in the globally important area of research.
3. Policymakers can formulate policies rethink and strategize foreign policy by looking at the collaborative and patent-cited metrics.
4. The bibliometric parameters analyzed in the study will enrich the university administrators in formulating new research policies and identifying funding sponsors to evaluate and strategize new research-incentive policies for the commercialization of research.

The outcome of this study can be used for government-level discussions for changes in foreign

policy for the improvement of collaborative research and infrastructure. Impact study of funding outcome from the acknowledgment text in Scopus is a new way of study in bibliometrics. Scopus database covers a large number of journals in comparison with other databases. Therefore, the funding details from Scopus gave a large coverage to Indian funding agencies. In this paper, we have introduced a new approach to the funding text data. We have retrieved the data from Scopus and for analysis; we implemented the method to import it to SciVal analytical tool. This technique gave us important information on the number of publications, 16 Sustainable Development Goals and their link to the funding agencies, different quality metrics like citations, Quartile of Journals selected for publishing, years of growth, etc. The result of the study has many consequences, which is important for funding agencies, researchers, and institutions. Below are the potential recommendations for further research:

1. Complementary analyses could be conducted to know the fellowship distributions by funding agencies.
2. Funding agencies should look seriously at the data on the relation between 16 SDGs and future thrust areas of R&D programs.
3. Researchers and Institutions can create databases through which they can find the relationship between sanctioned funds and funding outcomes.
4. Future research should be carried out with external collaborations (International and National) involving more than research funding agencies.

Acknowledgment

- This work is executed under the research project entitled "Influence of Government Policies and Funding on the Research Output of Government and Private Institutions in INDIA: A Bibliometric and Scientometric Study, Govt. of India, under NSTMIS scheme, Ref. (No. DST/NSTMIS/ 05/41/2017-18 dated 28.02.2019)
- For Data and Metrics, we are thankful to Scopus and SciVal

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