

Research contribution of major centrally funded institution systems of India

Anurag Kanaujia, Prashasti Singh, Abhirup Nandy and Vivek Kumar Singh*

India is now one of the major knowledge producers in the world, ranking among the top five countries in total research output. The institutional set-up for research and development (R&D) in the country comprises a diverse set, including universities, Government departments, research laboratories and private sector institutions. It may be noted that more than 45% share of India's gross expenditure on R&D comes from the Central Government. In this context, this article explores the quantum of research contribution of centrally funded institutions and institution systems in India. The volume, proportionate share and growth patterns of research publications from the major centrally funded institutions, organized in 16 groups, are analysed. These institutions account for 67.54% of the country's research output from 2001 to 2020. The research output of the centrally funded institutions in India has increased steadily since 2001, with a good value for compounded annual growth rate. This article presents noteworthy insights into the scientific research production of India that may be useful to policymakers, researchers and science practitioners. It presents a case for increased activity by the state governments and private sector to further the cause of sustainable and inclusive R&D in the country.

Keywords: Central government, gross expenditure, institution systems, knowledge production, research and development.

THE Indian research and development (R&D) system consists of various organizations, such as universities, Government research laboratories, autonomous organizations, private research laboratories and centres, etc. Recent information from the University Grants Commission (UGC), New Delhi, suggests that there are 1043 universities and about 40,000 affiliated colleges in the country (as on 18 June 2021; <https://www.ugc.ac.in/oldpdf/consolidated%20list%20of%20all%20universities.pdf>). Currently, this system consists of 54 central, 429 state, 125 deemed and 380 private universities and more than 150 institutes of National Importance. These cater to activities related to various disciplines (such as arts, languages, sciences, social sciences, humanities, etc.) and receive financial support from different sources. In addition, there are well-established institutional systems with significant contributions to the national R&D output. These include the laboratories/centres under the Council for Scientific and Industrial Research (CSIR), Defence Research and Development Organisation (DRDO), Indian Council for Agricultural Research (ICAR), Department of Atomic Energy (DAE), etc. There are various sources of R&D funding as well as various R&D models which are followed by these organizations. The major portion of funding for R&D, however, is provided by the Central and

State governments. Their contributions account for 51.8% of the total annual gross expenditure of R&D in the country (Figure 1), while the private sector accounts for about 37% of gross expenditure on research and development (GERD). In this context, the proportionate contribution of the centrally funded and private funded institutions and institution systems in the total research output of India is not well ascertained.

Several previous studies have explored the research productivity of various institutional groups such as Central Universities (CUs)^{1,2}, Indian Institutes of Technology (IITs)³⁻⁵, National Institute of Technology (NITs)^{6,7}, Indian Institutes of Science Education and Research (IISERs)⁸, private universities^{9,10}, and research-intensive higher education institutions (HEIs)^{11,12}. Some other studies also focused on analysing the research performance of India at an overall or broader level in different contexts¹³⁻¹⁶. To the best of our knowledge, there are no studies measuring and comparing the research output of all of the centrally funded institutions to the overall research output from India. Therefore, in the present study, we give an analytical account of the research output from India's major centrally funded institutions and institution systems.

Overview of the centrally funded institution systems

The Indian centrally funded institutional systems comprise a diverse set of institutions and institution systems. For this

The authors are in the Department of Computer Science, Banaras Hindu University, Varanasi 221 005, India.

*For correspondence. (e-mail: vivekks12@gmail.com)

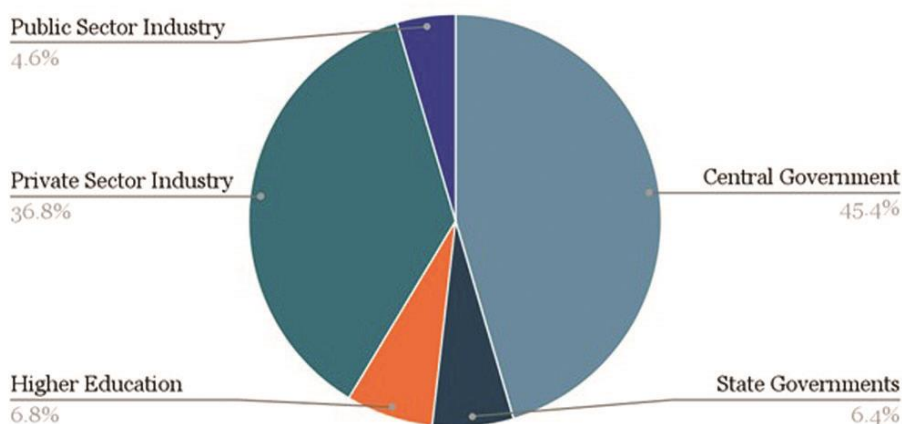


Figure 1. Relative percentage of gross expenditure on research and development (GERD) share of different sectors of STI in India, 2018–19. (Source: NSTMIS, Department of Science and Technology, Government of India, 2021 (ref. 17).)

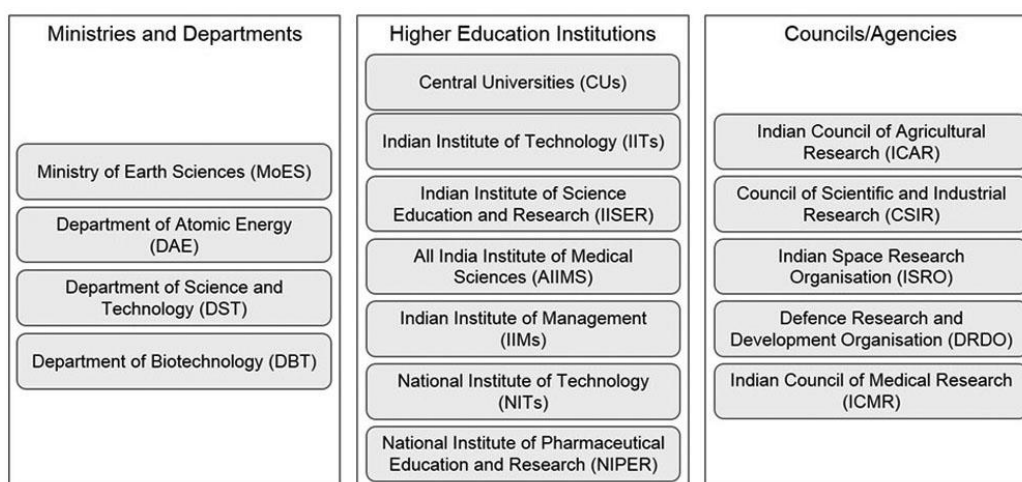


Figure 2. Indicative categorization of institutions considered in this study.

analysis, we have grouped them into three categories: (i) Ministries, Departments and autonomous organizations under them, (ii) HEIs funded by the Central Government, and (iii) Councils and Agencies maintaining different institutions (Figure 2). Although CSIR and DRDO are also accorded Department status, we have put them under the third category as they maintain many institutions and laboratories. Among these, four Ministries/Departments have a total of 71 institutions (Ministry of Earth Sciences (MoES) (9), DAE (17), Department of Science and Technology (DST) (23), Department of Biotechnology (DBT) (22)). The second category includes HEIs, which comprise 138 entities (CU (36), IITs (23), NITs (31), Indian Institutes of Management (IIMs) (20), IISERs (6), All India Institute of Medical Sciences (AIIMS) (8), National Institute of Pharmaceutical Education and Research (NIPER) (7)). The third category includes five Councils/Agencies having 439 institutions (CSIR (43), ICAR (95), Indian Council of Medical Research (ICMR) (31), Indian Space Research Organisation (ISRO)

(16), DRDO (61)). It may be noted that some categories do not exhaustively include all institutions, as those institutions that do not have significant research output in the Web of Science (WoS) database are left out. For example, under the CU category, Maulana Azad National Urdu University (MANUU), Mahatma Gandhi Antarrashtriya Hindi Vishwavidyalaya (MGAHV), etc. are not included in WoS due to the low volume of scientific research output. Appendix 1 ([Supplementary Material](#)) gives a detailed list of over 400 institutions categorized into 16 groups.

Objectives

The present study aims to answer the following research questions:

- (1) What is the overall contribution of centrally funded institutions and institution systems to the total research output of India during 2001–20?

Table 1. Research output of institution systems during 2001–20

Institution system	Number of institutions	TP (2001–20)	Percentage share to national output (%)	Compounded annual growth rate (CAGR) (%)
Indian Institute of Technology	23	152,276	15.8	11.56
Council of Scientific and Industrial Research	43	99,430	10.32	6.38
Central University	36	97,524	10.12	9.82
Department of Atomic Energy	17	77,819	8.07	7.22
National Institute of Technology	31	46,034	4.78	23.05
Indian Council of Agricultural Research	95	44,733	4.64	8.67
Department of Science and Technology	23	33,818	3.51	5.61
Indian Space Research Organisation	19	22,666	2.35	6.51
All India Institute of Medical Sciences	8	15,654	1.62	9.00
Defence Research and Development Organisation	61	13,285	1.38	6.12
Department of Biotechnology	24	13,262	1.38	8.74
Indian Institute of Science Education and Research	6	11,556	1.2	57.80*
Indian Council of Medical Research	31	11,061	1.15	7.79
Ministry of Earth Sciences	10	5,786	0.6	12.18
Indian Institute of Management	20	3,248	0.34	15.26
National Institute of Pharmaceutical Education and Research	7	2,732	0.28	10.91

Percentage share corresponds to India’s research output of 963,709 publications (article + review) during 2001–20.

*CAGR taken from 2006 to 2020 as first instance of publications in 2006.

- (2) Which institutions and institution systems show a higher growth rate of research output, measured in volume and proportionate share?

$$CAGR = \left(\left(\frac{V_{\text{final}}}{V_{\text{begin}}} \right)^{1/t} - 1 \right) * 100,$$

Data and method

The data for analysis correspond to research publications (article and review document types) from various centrally funded institutions and institution systems in India. WoS has been used as the source of research publication data. For the purpose of obtaining data, a list of centrally funded institution systems was prepared after checking the institution websites and other relevant reports and documents. Data for a total of 16 institution systems/groups consisting of 454 individual institutions were obtained. It may be noted that WoS does not have an appropriate institution system grouping for most institutions. Therefore, data for the institutions were downloaded individually. Data for the period 2001–2020 were downloaded for all the individual institutions as well as for India as a whole. Data download was done in April 2022. The following search queries were used: (a) PY=(2001–2020) AND CU=“India” AND DT=(“Article” OR “Review”) to collect research output data for India, and (b) PY=(2001–2020) AND CU=“India” AND OG=X AND DT=(“Article” OR “Review”) to collect data on the research output of individual institutions. Here PY is the publication year, OG the organization, DT the document type and CU is the country, which is India in the present case. X is the name of the institution sought.

The publication data obtained from WoS were analysed using Python. The standard indicators of total research output, proportionate share and compounded annual growth rate (CAGR) were computed for all the institution groups. The CAGR of institutions was calculated as follows

where V_{final} is the number of publication records in 2019, V_{begin} is the number of publication records in the year when the first research output of the institution was seen, and t is the time period between the first and latest publications (in years). The various results were computed for the 16 major identified institution systems. The proportionate contribution of each institution system to India’s total research output was identified. The data were divided into four different blocks of five years each. The pattern of growth and CAGR value for all institution systems were computed and plotted. Next, the change in the proportionate contribution of each institution system during the four blocks was observed.

Research contribution of centrally funded institution systems

The analytical results described below present the research output volume of each institution system along with its proportionate share of India’s research output. Thereafter, the patterns of growth of research output of the institution systems are presented.

Research output volume of each institution system between 2001 and 2020

Table 1 presents the total number of publications, percentage share of the national output and CAGR of all the institution systems considered here. The IIT system was the largest contributor, with a total of 152,276 papers during 2001–20. It

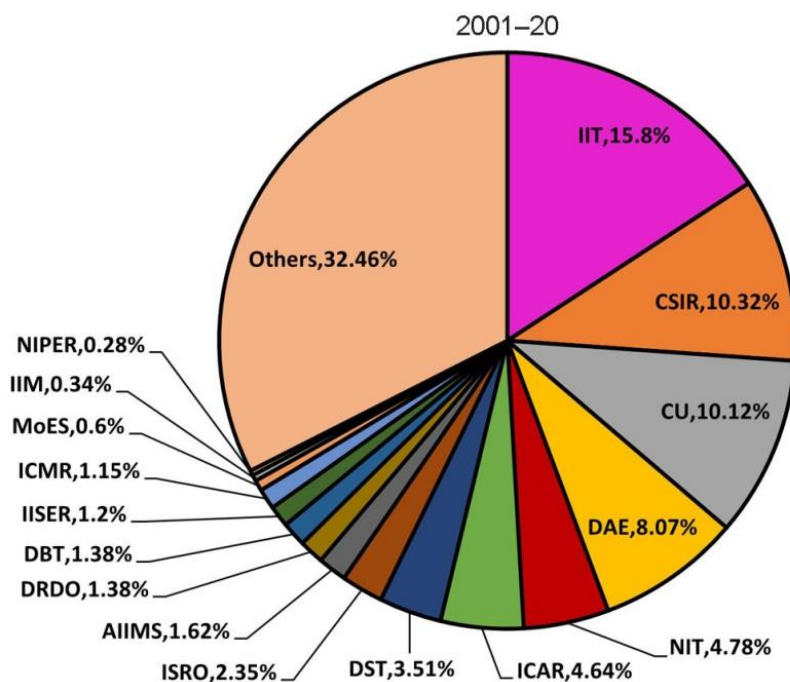


Figure 3. Percentage contribution of selected institution systems to India's research output from 2001 to 2020. The highest contributions were made by IITs, CSIR laboratories and CUs, all contributing more than 10%.

was followed by CSIR (99,430), CUs (97,524), DAE (77,819), NITs (46,034) and ICAR (44,733). The 23 institutions of DST combined contributed 33,818 papers. In terms of percentage share of India's total output during this period, the IIT system contributed 15.8, followed by CSIR with 10.32 and CUs with 10.12. The IISER and NIT systems recorded impressive CAGR values. It may be relevant here that the institution systems like CSIR, ISRO and DRDO engage in technology development and research activities. Similarly, the HEI systems like IITs, CUs, NITs, etc. engage in teaching and research. The relative emphasis of different institution systems on research and other activities is different. Further, the institution systems vary significantly in terms of the number of full-time researchers and availability of resources. Therefore, the results should not be seen as an effort to compare the research output of these institutions; rather, they should be seen in terms of their contribution to India's total research output for the study period.

The percentage share of each institution system in the overall national output was calculated and plotted on a pie chart for better understanding (Figure 3). The top six systems contributed over 50% of the total output. All the centrally funded institution systems combined contributed 67.54% of the total research output of India during the period. Among the top contributors, IITs, CSIR laboratories and CUs had more than 10% share each. Although the contribution of NITs (4.78%), IISERs (1.2%) and IIMs (0.34%) were low, a steep rise in their publications was observed. The CAGR values for these were higher than other systems (23.05% for NITs, 57.80% for IISERs and 15.26% of IIMs).

Patterns of growth in research output

To understand the pattern of growth in research output from each institution system, a set of bar charts is shown in Figure 4 for four blocks of five years each for all the institution systems. The individual research output of the group of institutions showed an increase in all the cases. IITs, NITs, IISERs and IIMs showed rapid growth in their research output, with a twofold increase in the number of publications between 2011–15 and 2016–20. While the publications of other institutions had increased, NIPER stagnated in the period between 2011 and 2020. The IIT, CSIR, CU and DAE systems consistently grew in all four blocks. The ICAR, DST, ISRO and DBT systems also showed overall growth in all the four blocks. Thus, in overall terms, the majority of the institution systems recorded noticeable growth in research output during the period 2001–20.

Figure 5 shows the proportionate share of research contribution of each institution system to India's total output. The pie charts are shown for four different time periods, 2001–05, 2006–10, 2011–15 and 2016–20. It can be observed that the proportionate share of the IIT system had increased from 12.56% in 2001–05 to 18.72% in 2016–20. On the other hand, the proportionate contribution of the CSIR system has decreased continuously during the period, decreasing to 9.14% in 2016–20 from 12.43% in 2001–05. The CU system also showed a marginal increase in proportionate share during the first three blocks and a stagnation at the same level in the fourth block. The DAE system

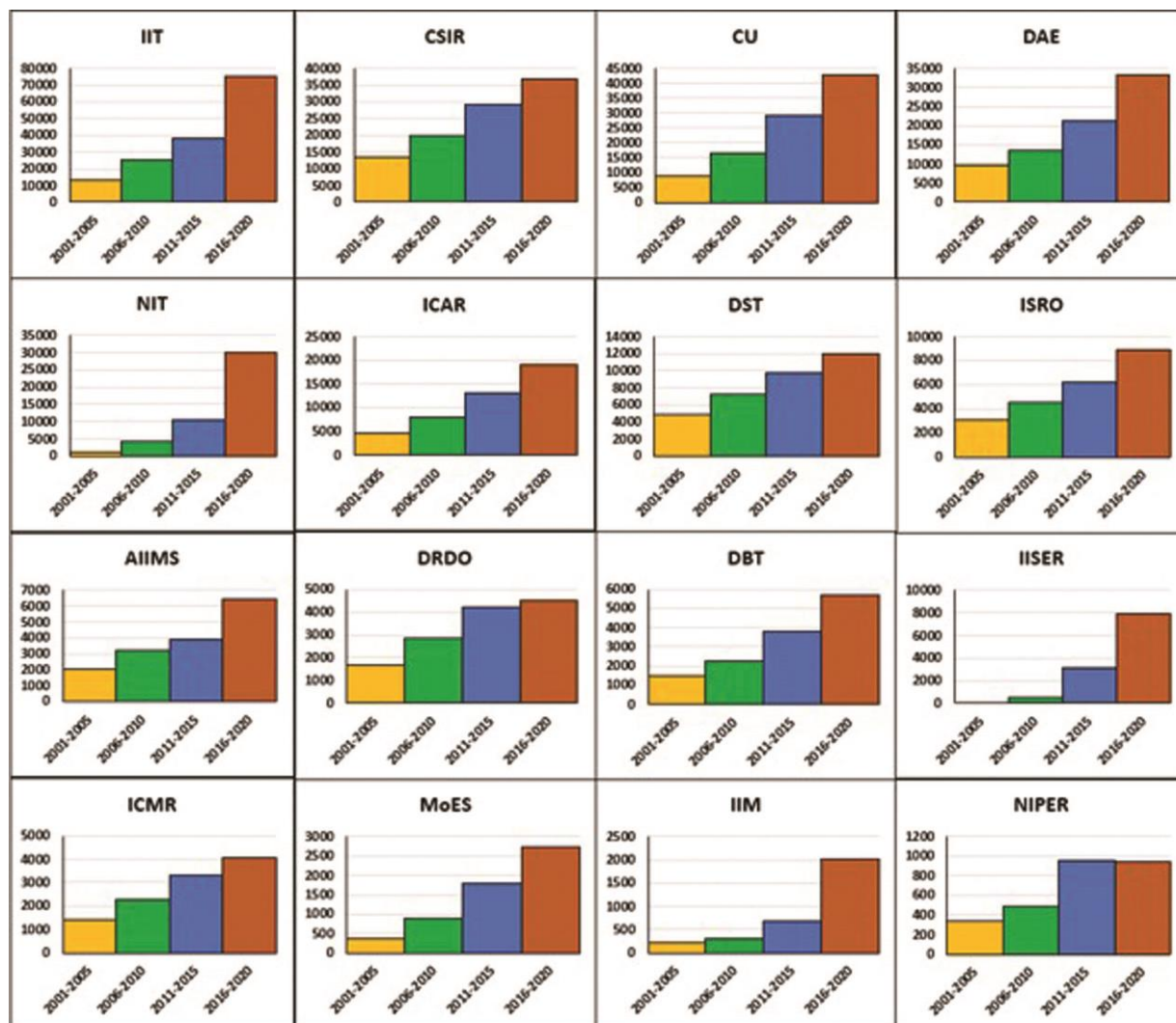


Figure 4. Research output of each group of institutions during 2001–20.

showed a mixed pattern of decline and then growth in proportionate share. The NIT system had improved its percentage share significantly, increasing from just 1.03% in 2001–05 to 7.5% in 2016–20. This is an impressive growth of research output for any system. The ICAR system’s proportionate share remained constant at the same level during the period. The proportionate share had remained largely unchanged in the case of other institution systems too, namely DAE, ICAR, ISRO, AIIMS, DRDO, DBT, ICMR and NIPER. Over the 20-year period, the contribution of the remaining institutions had reduced from 37.54% in 2001–06 to 27.3% in 2016–20, implying that the central institution systems combined have increased their contribution.

Discussion and conclusions

In this article, we have analysed the research contribution of major centrally funded institution systems to India’s total research output during 2001–20. It was observed that the

research contribution of centrally funded institutions increased from 62.46% in 2001–06 to 72.7% in 2016–20. Almost all major institutions had recorded growth in their research output during the study period. However, in proportionate share, some institutions (such as IITs and NITs) showed significant growth, while the proportionate share of some other institutions (such as CSIR and DRDO) had decreased slightly. There could be two probable explanations for this. First, since more institutions have been added to some of the systems, like IIT and NIT, in the study period, their total research output has increased much faster. Second, most institution systems have also recorded a genuine growth in research productivity in this period. Thus, overall, there was an increase in both, the volume of research output and proportionate share of the major centrally funded institution systems.

The relatively low proportionate share of institution systems like DRDO, ISRO, DST, DBT and ICMR is an interesting point of observation. Unlike what one may expect,

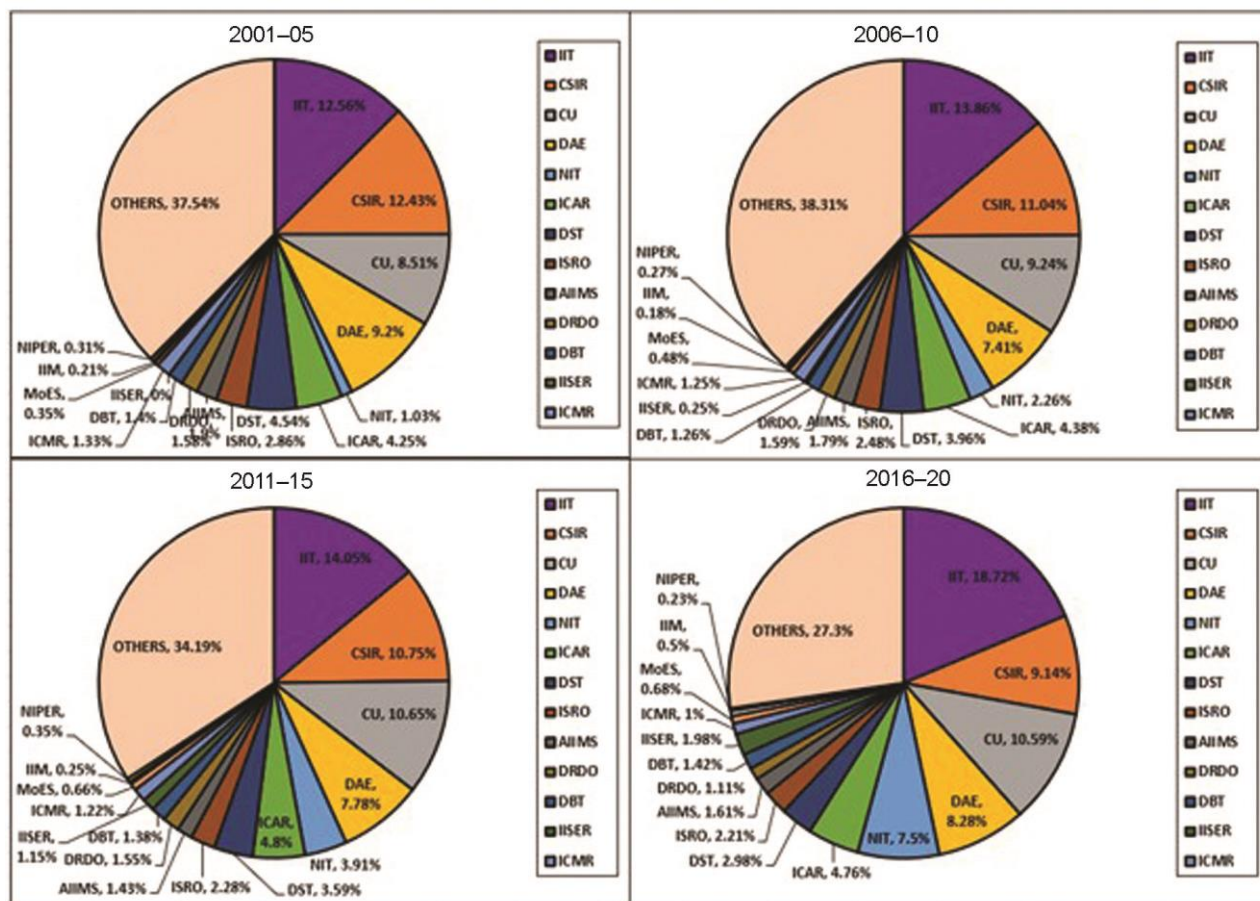


Figure 5. Proportional research publications from centrally funded institutions in five-year intervals starting from 2001. These institutions contributed to more than 60% of the research publications.

these institutions do not have a very high research output. This may be explained due to the fact that these organizations engage in different kinds of R&D activities, all of which do not result in a research publication. In this sense, this article has a limitation that it only considers research papers, and ignores other R&D outputs (such as patents, technologies developed, etc.). A more detailed analysis of the research contribution of the institutions would thus need data about patents and technologies developed. Interestingly, the institutions of higher learning (such as IITs, NITs, CUs, IISERs, etc.) have published more research papers. This indicates that the Indian HEIs are now more seriously engaging in research activities, which often lead to research papers as outputs. Irrespective of these observations, one may note that the major centrally funded institution systems contributed approximately two-thirds of the total research output of India. The combined output of all other institutions (under various state governments and private sector) was just about one-third of national output. The number of institutions under state governments and the private sector will be many times more than the total number of centrally funded institutions. Yet their research output is less. Thus, the results indicate that centrally funded institutions have an

important role in India's R&D activities, and that state governments should strive to promote more such activities in their institutions.

In recent times, the Government of India has taken various initiatives to increase allocation in the field of science and technology (S&T), such as successive increase in plan allocations for scientific departments, setting up of new institutions for science education and research, creation of centres of excellence and facilities in emerging and frontline areas of S&T in academic and national institutions, supporting mega facilities for basic research, providing new fellowships, substantial grants to potential scientists through extramural research funding, scaled-up funding in the new areas of research such as clean energy and water, including energy efficiency, clean coal technology, smart grids, methanol, desalination, genome engineering technology, climate change research, National Supercomputing Mission, National Mission on Interdisciplinary Cyber Physical System, promotion of innovation, entrepreneurship and start-up grants for young scientists, Funds for Improvement of S&T Infrastructure, encouraging public-private partnerships, fiscal incentives and support measures for enhancing the participation of industry in R&D, to name a few. These initiatives could have

directly or indirectly helped in promoting R&D activities in Indian institutions, particularly institutions under the Central Government seem to be the major beneficiaries.

In light of this information, in India, the role of stakeholders such as the Government and funding agencies is important in ensuring higher productivity from centrally funded institutions as well as increasing the contribution of state and private funded institutions in research. Institutions under the state governments constitute a large share and an improvement in the research culture in those institutions will result in a manifold increase in India's research output. It is equally important that government and private stakeholders work together in a collaborative and complementary manner to ensure holistic growth in the R&D capabilities of Indian institutions.

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Received 2 August 2022; accepted 27 August 2022

doi: 10.18520/cs/v123/i9/1082-1088