Research Funding

for STEM Higher Education Institutions

An Analysis of India vs International Models

Centre for CIVIL SOCIETY
SOCIAL CHANGE THROUGH PUBLIC POLICY

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Research Funding for STEM Higher Education Institutions: *An Analysis of India vs International Models*

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List of Abbreviations

AIIMS	All India Institute of Medical Sciences
CAR	Centres of Advanced Research
CRG	Core Research Grant (under SERB)
CSIR	Council of Scientific & Industrial Research
CSTP	Council for Science and Technology Policy
DAE	Department of Atomic Energy
DBT	Department of Biotechnology
DFG	Deutsche Forschungsgemeinschaft (Research Funding Organisation)
DSIR	Department of Scientific & Industrial Research
DST	Department of Science & Technology
EAC-PM	Economic Advisory Council to The Prime Minister
EU	European Union
FTE	Full Time Equivalent
GBARD	Government budget allocations for R&D
GERD	Gross Expenditure on Research & Development
GUF	General University Fund
HEI	Higher Education Institution
IAI	Independent Administrative Institutions
ICMR	Indian Council of Medical Research
IIT	Indian Institute of Technology
IISc	Indian Institute of Science
IISER	Indian Institute of Science Education and Research
INAE	Indian National Academy of Engineering
INSA	Indian National Science Academy
IMPRINT	Impacting Research Innovation & Technology
IRHPA	Intensification of Research in High Priority Area
IYBA	Innovative Young Biotechnologist Award
KICOS	Korea Foundation for International Cooperation of Science and Technology
KOSEF	Korea Science and Engineering Foundation
KRF	Korea Research Foundation
LTREB	Long Term Research in Environmental Biology
MD	Doctor of Medicine
MoE	Ministry of Education
MoF	Ministry of Finance

MOSPI	Ministry of Statistics and Programme Implementation
MoST	Ministry of Science and Technology
MEXT	Ministry of Education, Culture, Sports, Science and Technology, Japan (Monka)
NDRC	National Development and Reform Commission
NET	National Eligibility Test
NIH	National Institutes of Health
NRF	National Research Foundation
NSAI	National Academy of Sciences, India
NSF	National Science Foundation
OBC	Other Backward Classes
OECD	Organisation for Economic Co
PhD	Doctor of Philosophy
PPP	Purchasing power parity
R&D	Research and Development
SCI	Science Citation Index (SCI)
SC	Scheduled Castes
S&T	Science and Technology
SSB	Shanti Swarup Bhatnagar Prize
ST	Scheduled Tribes
STEM	Science, Technology, Engineering and Mathematics
STI	Science, Technology & Innovation
TRAC	Transparent Approach to Costing
UAY	Ucchatar Avishkar Yojana
UGC	University Grants Commission
UK	United Kingdom
UKRI	UK Research and Innovation
UNESCO	United Nations Educational, Scientific and Cultural Organization
UT	Union Territory

Executive Summary

Researchers across the globe often face a dilemma of ambiguity about and inadequacy of funding for their projects. In India too, despite the increase in the overall amount of research funding over the years, it continues to remain insufficient and difficult to utilise by university-based researchers.

Many of these issues point towards the lack of well-defined processes and procedures to capitalise on the country's research funding model. In order to enhance India's overall investment in research, we need to study each component of the Science and technology ecosystem that contributes to the performance of Research & Development (R&D). This report attempts to focus on India's universities and innovative young minds therein who form the essential staple for the research ecosystem.

The report examines project-based R&D funds received by India's leading higher education institutions through five major government research funding agencies (DST, DBT, SERB, ICMR, and CSIR) and compares the model with the funding models of top R&D performing countries. It aims to bring to light some of the pressing issues, often ignored, that obstruct the country's higher education sector from improving its performance in the R&D ecosystem.

The first half of the report, 'India in spotlight', deep-dives into the schemes & programs of five of the above-mentioned agencies. A detailed analysis has been undertaken in order to understand their application procedure, selection & eligibility criteria, components (permitted grant utilisation), duration and institutions funded. This is followed by the 'India vs International Models' section which provides a cross-country analysis of relevant statistics, the national research funding models for those countries and, provides a nuanced look at the individual traits of research funding across these countries. In addition to India, this section of the report analyses models of seven of the top countries known for their contribution to STEM research, namely Japan, USA, UK, South Korea, China, Germany and Israel.

The report brings forth the latent cry of decades of researchers and scientists in India. It argues that India's research funding model can only produce better results if we tackle the issues of transparency, lack of feedback mechanisms, ambiguous guidelines (both on description of the grant and utilisation of the grant) and have a rigorous monitoring & evaluation process. Significantly, it points towards the lack of consolidated data in the public domain that could be utilised by researchers and civil society to study and produce reports, make recommendations and to understand the higher education sector's role in R&D. For a country poised to become Atmanirbhar in this decade, periodically publishing granular data and statistical evidence on the R&D contribution of the higher education sector will give the muchneeded impetus to public participation and private investment in university-based research.

Introduction

As a measure of critical rigour, quality education and overall capacity, the research in Higher Education Institutions (HEIs) plays a vital role in a country's R&D ecosystem. For several decades now, the Indian government has been aiming to increase India's R&D expenditure to 2% of the GDP and a part of this investment includes the expenditure on the R&D performed at the HEIs. The upcoming National Research Foundation (NRF) also highlights the intent of the government to enhance funding for research and facilitate capacity-building for R&D across the country.

One of the biggest regrets of the Indian STEM research ecosystem has been the lack of alignment or vision for linking the research and the education sectors as part of the country's initial post-independence policies. The consequence of this continues to be visible in the subscale role that the education sector plays in the country's R&D performance and expenditure.

In the past few years, R&D performed by HEIs (or the university-based R&D) as a percentage of total national R&D for the major countries in the world ranged from 4% to 26%, with India lying on the lower end of this spectrum, with a mere 4% university-based R&D (NSF 2018). The two major economies, the United States and China were at 13% and 7% respectively whereas the European economies of the United Kingdom (26%), France (20%) and Germany (17%) also had a considerably high R&D being performed in their HEIs. The Asian economies of South Korea and Japan also performed fairly well with 9% and 12%, respectively (Ibid).

At the core of this issue of low spending for India is the unavailability of comparable data in relation to research spending. Currently, there is no publically available consolidated data on the institution-wise R&D expenditure and research grants made to specific HEIs by any of the national funding agencies. As per the R&D Ecosystem report by the Economic Advisory Council to The Prime Minister (EAC-PM), although there is no comprehensive data available on R&D expenditure in HEIs in the public domain, the entity responsible for it the Ministry of Education (MoE), does make available information on the top five institutions and the amount spent by them on R&D, all five of which are IITs (EAC-PM 2019). Moreover, the HEIs themselves do not publish consolidated data on grants received from the funding agencies nor the details of the R&D expenditure made by them.

Hence, there is a visible paucity of information about the scenario of R&D funding in the higher education sector of the country and this must be addressed as a matter of urgency in order to create evidence-based policies for the sector, ever so important given that the much-awaited NRF is currently at the stage of conceptualisation.

Scope & Aim

Through this study, we performed an analysis of the project-based research funding models that currently exist in various countries, to understand the contrast between India's research funding model vis-à-vis models of other countries for university-based R&D. Due to the gaps in data collection for R&D performed by the higher education sector, this report does not provide an analysis of the exact figures of allocated funds but is instead concerned with the other intricacies of the research funding schemes and grants being made. These issues range from autonomy of utilisation of funds, the eligibility criteria, the selection criteria, the components of grants and the duration of grants, to name a few. The research funding allocated at the state/provincial levels has not been included in the scope of this study and might differ significantly from region to region.

The first half of the report includes a study of funding schemes, fellowships and programs run by five of the top national funding agencies of India, namely, DBT, DST, CSIR, ICMR and SERB. Research projects that receive funding from national-international collaboration schemes/joint programs or government-private joint funding programs have been kept out of the purview of this study since the nature (in funding or as a knowledge support or any other) and structure (private-public, multi-agency etc) of these programs can vary significantly worldwide, making the comparisons difficult.

The latter half of the study is dedicated to international comparisons of research funding models across countries and their common and/or contrasting characteristics. The section also analyses country-wise statistics and provides an overview of national academic research funding models of certain other foreign economies. Countries included as part of this 'India vs International models' study are the ones that have been globally known for their contribution to STEM research & development as well as, not surprisingly, having a high gross expenditure on R&D (GERD), along with a few other parameters.

The report concludes by providing relevant recommendations to facilitate the 'ease of research grant management' in higher education institutions of India while also leveraging the learnings from other countries who have a flourishing university-based R&D. The lack of data on university-based R&D, a need for autonomy in utilisation of research grants, lack of availability of long-term research funding and the need for transparency in the research funding allocation system are some of the pertinent issues this report tables and touches upon.

Literature Review: The Tale of 7 Countries

Globally, funding models for university research are often classified based on the idea of the degree to which they are supported by internal or external funding (Irvine et al. 1990). Governments typically have two main modes of direct investment in university-based R&D: Institutional and Project-based. Institutional investment can help ensure stable long-run investment in research, while project-based investment can promote competition within the research system and strategic target areas. Institutional funding generally provides the institutions with more scope to shape their own research agenda, while project funding provides governments with more scope to steer research towards certain fields or issues. This is attributed to the fact that in most cases, it is a lump sum amount (a common block grant) for both education and research (Jongbloed & Lepori 2015). On the other hand, project funding may allow governments to target the best research groups or support structural change (Vught & Jongbloed 2013).

A study of the research funding models across countries reveals interesting variations. Most countries in Europe tend to cover only the direct costs plus overhead costs (usually fixed) related to the research. As a consequence, institutions tend to rely on state allocated core funds/institutional grants for a large portion of the general research expenses (Jongbloed & Lepori 2015). A study by the Organisation for Economic Co-operation and Development (OECD) found that out of 17 countries included in the study, project funding comprised more than 50% of the public research funding in 5 of those countries and ranged between 23% to 50% in the rest of the 12 countries (van Steen 2012), showing a reliance on the state-level funding for general expenses. This is an important aspect of research funding that has often been overlooked in India. Another interesting finding is the deployment of performance-based research funding.

Performance-based research funding: The performance-based research funding is the equivalent of 'pay for results' and has become a characteristic of not just project-based funding but also many institutional core grants. For example, in the United Kingdom, findings from the national research assessments tend to drive a portion of the block grant (core funding) received by a university. Few countries have also introduced performance contracts between the HEIs and the funding agencies for the core funding to be awarded in line with institution specific/mission oriented objectives that are in turn, aligned with the country's national priorities (Ibid). The performance-based funding systems differ widely, both in the nature of funding and in terms of the type of assessments they use. For example, the use of a funding formula can be observed in the models of various European Union (EU) member states like Poland, Finland, Denmark, Sweden etc. These are partially based on the quantitative assessment of research outputs. Another set of countries base their funding formulae instead on evaluations of research output through peer review (Jonkers & Zacharewicz 2016).

Over the last few years, university-sector research funding has evolved differently across countries. In a US study specific to the National Institutes of Health (NIH) budget, it was seen that highly research-intensive and PhD-granting universities responded to decreasing availability of federal funds by substituting funding from non-federal sources (Sood et al. 2015). It is therefore clear that the governmental core funds are increasingly in favour of the idea of performance which has resulted in the funding agencies adopting mission-oriented and contract-based strategic allocation procedures.

A European Commission study examining funding diversification using a sample of 200 universities to determine the structure of university budgets found that for the average European research-intensive university, a major proportion of the total university income came from government grants. Among other sources, the private companies provided ~ 6%, the non-profit sectors provided ~3% and ~2% came from foreign funding (Vught & Jongbloed 2013). The insight here is that the share of direct government funding has gradually decreased while the share of external and industrial funding has increased, even though governmental funding remains the predominant source of funding for university research.

There are country-specific funding environments, which vary due to different funding sources, their shares of total funding and involved incentives (Auranen & Nieminen 2010). For instance, there is no single model for the American research university—a set of institutions that includes public and private variants that range considerably in scale, from private institutions, like Dartmouth and Caltech, to large public universities, like Ohio State. The UK government, too, funds research in universities through what is known as the 'dual support' mechanism. This comprises an annual grant from the funding councils to support the research infrastructure and specific project grants from the research councils for funding particular pieces of research.

Addressing the role that public funding has played in one of India's neighbouring countries, China reveals a valuable insight. A research published in 2020 concluded that a higher research output was observed as a result of major upgrades being made in 2011 to China's National Natural Science Foundation—a major public research funding agency of the country. Not only did it facilitate collaborations among the top and the lesser-known universities of the country but also benefited the researchers earlier considered to be less-established (Hu 2020). Another Asian economy considered to be a significant contributor to the global S&T ecosystem is Japan. Fumihiro Maruyama (2007) in his paper 'Financing Universities in Japan' highlights the autonomy possessed by Japanese universities as result of a reform in 2004 that gave them an independent corporate status and a discretion on how they wish to internally allocate operational grants received by them from Japan's Ministry of Education, Culture, Sports, Science and Technology (MEXT).

Several studies across the globe have attempted to analyse the relation between government research funding and research productivity. These studies range from assessing research productivity of individual researchers to assessing it for universities performing R&D. However, the purpose of this study is quite different. Through this study, we aim to perform a detailed analysis of the funding models that currently exist in various countries, to understand the contrast between India's research funding model vis-a-vis models of other countries for project-based R&D in HEIs. We aim to create literature that will help us (and others like us who strive to liberalise the STEM R&D ecosystem in India) identify India's strengths and weaknesses with respect to funding models and thereby create a strong case for corrective action to the policies that are presently being crafted in the STEM policy space.

Methodology

In order to understand the STEM R&D funding landscape in India and abroad, the study looked at findings of existing literature, published reports and statistics by renowned bodies such as DST & EAC-PM (for India), OECD, EU and NSF (for USA-centric and global data). The focus of this report has been on schemes and programs for project-based funding by federal governments in broad areas of Science and Technology, rather than specific subfields.

India's Model: The Big five

To understand which schemes in the STEM R&D ecosystem are the most relevant ones to focus on, we chose STEM INIs and other eminent institutes as our starting point. These included IITs, IISERs, , AIIMS, IISc and some ICARs. Upon a preliminary study of the websites of these institutes, some landmark events/ schemes came up. Most of the STEM R&D projects based out of these institutions studied were getting their funding from schemes of just the following 5 funding agencies:

1. Department of Science and Technology (DST)
2. Department of Biotechnology (DBT)
3. Indian Council of Medical Research (ICMR)
4. Science Engineering and Research Board (SERB)
5. Council of Scientific and Industrial Research (CSIR)

In the second stage of the analysis, an inspection of the statistics published by DST in the R&D Statistics report corroborated the prominence of these 5 funding agencies in the overall STEM R&D ecosystem of India. HEIs funded by the Department of Atomic Energy (DAE) are limited, as also observed during the first stage of our study. Further, details on expenditure incurred by Defence Research and Development Organisation (DRDO) on HEI-based R&D was not available due to which conclusions regarding its impact on the funding landscape in academic research could not be drawn satisfactorily. Hence, the DAE and DRDO were excluded from consideration. Prominent schemes of the shortlisted 5 funding agencies that popularly fund the leading HEIs in India were identified and analysed in detail. (For a list of the schemes studied, please refer to Appendix A).

The burden of funding STEM R&D for HEIs largely with just 5 public agencies poses the question of whether there is opportunity being lost due to this model. A deeper dive into international models reveals the opportunity that lurks within.

Table 1: Expenditure of R&D by National Funding Agencies of India

(Source: Research & Development Statistics 2019-20, Department of Science and Technology)

NAME OF FUNDING AGENCY	EXPENDITURE ON R&D (Rs. Crore)	
	2016-17	2017-18
Council of Scientific & Industrial Research (CSIR)	4013.06	4582.12
Defence Research and Development Organisation (DRDO)	13382.05	15195.87
Department of Atomic Energy (DAE)	4750.39	5208.01
Department of Biotechnology (DBT)	1446.71	1771.65
Department of Science and Technology (DST)	3161.54	3526.64
Indian Council of Agricultural Research (ICAR)	4592.95	5355.57
Indian Council of Medical Research (ICMR)	1073.83	1468.7

International Model

We shortlisted 7 countries on the basis of their R&D performance, research productivity, Gross expenditure on R&D (GERD) statistics, researchers per million and global recognition as important players in the R&D ecosystem. The report adopts a comparative approach to evaluate where India's public R&D expenditure stands with respect to global standards. In order to understand the similarities and contrasts among varying systems the best, the following countries have been selected for comparisons:

- United States of America
- China
- Japan
- Germany
- South Korea
- Israel
- United Kingdom

For a systematic study of the funding models of these countries, the following parameters have been used as common reference points: Autonomy of fund utilisation, eligibility, duration of grants, components of the grants, selection of proposals and provision of feedback for all applicants.

Statistics: The USA and China are top R&D performing countries accounting for 25% and 23% of the global R&D expenditure respectively. Japan and Germany's R&D expenditure account for 8% and 6% of the global total respectively. These are followed by India (2.3%), the UK (2.27%) and other countries in the 2%-3% bracket (Boroush 2020). The gross domestic expenditures on R&D as a part of its GDP is the highest in South Korea (4.6%), followed by Israel (4.5%) (EAC-PM 2019). The funding models of these seven countries represent the essential systems and provisions that are successful in boosting research productivity and performance on other global indices.

Table 2: Expenditure of R&D as % of GDP by countries

(Source: Research & Development Statistics 2019-20, Department of Science and Technology)

Country	Expenditure on R&D as % of GDP
Republic of Korea	4.6
Israel	4.5
Japan	3.2
Germany	3.0
USA	2.8
United Kingdom	1.7
India	0.7

This comparative study highlights the variations among countries and their overall research funding models to present ideas and develop possibilities for India's STEM research ecosystem. In some instances, references are made to the contributions of the private sector to the R&D ecosystem to highlight India's unique scenario. The analysis of parameters such as autonomy of utilisation of funds, selection criteria, duration, etc from comparisons of public research funding models of various countries are recorded in the 'India vs International Models' section. The findings of the same have made their way into the recommendations provided at the end of this report.

Significantly, unlike most other countries studied in this report, India's government-funded/public R&D expenditure heavily outweighs private expenditure made for R&D. This points to a key cause for the underdeveloped STEM R&D ecosystem in India.

India in Spotlight

Background of STEM Research in India

The Constitution of India is one of the few constitutions in the world that encourages the citizens of India to have a sense of 'scientific temper'. According to the Fundamental Duties under Article 51 A (h): "[It shall be the duty of every citizen of India] To develop scientific temper, humanism and the spirit of inquiry and reform". Regrettably, most Indian universities and the education system in general, have been struggling to cultivate a 'scientific temper' in the students. A number of factors as under are responsible for this sorry state of affairs.

1. Poor scientific environment and lack of synergy between HEIs, industry and research agenda: Since the past few years, there has no doubt been an unprecedented growth in India's higher education system, with a substantial increase in the number of institutions, a rise in student enrolment rate, as well as a considerable increase in public funding. However, there has been inadequate focus and emphasis in the HEIs on quality of outcome, research and development, innovation, transparency, and originality, characteristics which have been the hallmark of a thriving STEM ecosystem elsewhere in the globe. Furthermore, the NITI Aayog (2018) in its report "Strategy for New India" revealed that there is a severe lack of interaction between the industry, research and HEIs. The continued isolation among HEIs and R&D have rendered India's STEM research ecosystem predominantly stagnant with suboptimal outcomes. Until recently IIT Madras remained the only premier institution in India that had a functional research park (a standard feature of many mid-sized universities the world over) that was developed as late as in 2010.

   The failure of most Indian universities in giving importance to top-notch research management support and the lack of stand-alone research offices in universities has only exacerbated the already existing problems in STEM research.

   The other issue is that of efficiency of the research process. It is essential that research projects receiving government funding are comprehensively monitored to discover ways and methods of making the entire system more efficient.

2. The role envisaged for STEM Research by HEIs: There is also an important conceptual issue here. The Ministry of Statistics and Programme Implementation (MOSPI) opines that "research and development is not an ancillary activity, and a separate establishment should be distinguished for it when possible" (EAC-PM 2019). It follows therefore that while teaching enhances the development of students, research advances the development of new knowledge. It is important for HEIs to have a clear distinction between R&D and teaching, conceptually to avoid significant practical challenges of divided labour, and yet, ensure considerable alignment and coordination between the two. Additionally, some intersections between teaching and research bring complications in distinguishing them, even theoretically (Ibid).

   Earlier, publications were majorly seen as the end goals of a research project. However, with increased interactions between industry and academia, this perspective towards research outputs has been greatly altered. In India, the indicators that are typically utilised to measure the STEM R&D ecosystem and gauge the effectiveness of existing policies and schemes demonstrate the bias towards theoretical research, with lesser practical filters (EAC-PM 2019): Patents - Filed and Granted, Research Publication Trends, Research Papers Published, India's ranking in scientific publication in Scopus, SCI and NSF Database

   As per Scopus (the largest abstract and citations database of research papers in the world), India ranks 6th in the number of papers published. And yet, the rank order in citations is at low 12th place, demonstrating the low research 'influence' we command. A key reason is the emphasis on quantity rather than utility/quality of the research work as an academic pursuit.

As per DST 2020 estimates, India's contribution to world publications stands at 3.8%. Certain variations exist among different fields and subfields of STEM research. Among these, India's contribution to publications in Chemistry is the highest at 7.2%. Contrarily, India's contribution to global publications is the lowest in the field of Neuroscience and Behaviour at 1.4% (DST, 2020). The commercial viability of the areas of research is a possible reason for low citations and low research 'influence' for India.

3. Few 'Keepers' of STEM Research; underutilization of HEIs: According to the Economic Survey (2017-18), more than half of R&D expenditure in India is incurred by the central government. The survey also ascertained that in top-performing R&D countries HEIs play a crucial role in R&D expenditure/investment and producing quality research output. On the other hand, in India, it has been observed that research funding has largely been focused on specialised research institutes. As a result, other universities are primarily responsible for and limited to teaching leaving them underutilised in the R&D sector. In this light, the Economic Survey (2017-18) suggested that national laboratories must be linked to universities in order to boo st the knowledge and research ecosystem.

However, India appears to be at the cusp of seeing the proverbial light at the end of a long tunnel, as the Ministry of Education (MoE) has been leading the mission to promote research in higher educational institutions. There are greenshoots of promoting greater academic and research networking within and between leading national educational institutions as well as strengthening the basis for industry-academia collaborative projects. Encouragingly, plans to execute the establishment of Research Parks, start-up and incubation centres, research financing through programs such as Impacting Research Innovation & Technology (IMPRINT) and Ucchatar Avishkar Yojana (UAY) are already in progress. There are lessons galore from countries around the world for India to learn from, and improve upon, as we carve the highway for greater scientific temper in our country.

India's National Funding Agencies

India's Ministry of Science and Technology is the dominant agency that is responsible for funding STEM R&D in India. Of the 5 agencies under consideration in this study, 4 bodies i.e. DST, DBT, SERB and CSIR are under the Ministry of Science and Technology while the Indian Council of Medical Research (ICMR) is an autonomous body under the Ministry of Health and Family Welfare. In this report, we have studied the following programs by these agencies with the view to form the basis for basis for comparing and contrasting the funding models that some leading countries are following:

DST
- Swarnajayanti Fellowship
- INSPIRE Faculty Fellowship
- Mission on Nano Science & Technology

DBT
- Ramalingaswami Re-Entry Fellowship IYBA
- S Ramachandran - National Bioscience Award for Career Development

SERB
- Core Research Grant
- Ramanujan Fellowship
- J C Bose Fellowship

ICMR
- Emeritus Scientist Scheme
- Cohort Studies
- Ad-hoc Project Funding

CSIR
- Emeritus Scientist Scheme
- Shanti Swarup Bhatnagar Prize

Funds Allocation & Expenditure by the Ministry of Science & Technology

The Ministry of Science and Technology's activities in India's R&D ecosystem are administered and managed via its three departments: DST, DBT and DSIR. CSIR is an autonomous body under DSIR. India's Union Budget 2021-22 allocated Rs. 14,794 crores to the Ministry of Science and Technology , of which 41% has been allotted to DST, 35% to DSIR and 24% to DBT.

Of the total amount allotted to DST, ~14% of funds have been allotted to SERB. In the case of DSIR, almost 98% of the funds have been directed to CSIR (PRS Legislative Research, 2021). As compared to 2019-20 figures, funds for DBT have increased by 22% while the rate of increase has been 6% for DST and 4% for DSIR in the same period. Increased allocations for vaccine development and production may be one of the possible reasons for the varied trends in allocation. In 2020-21, DBT spent Rs. 75 crores to support 8 vaccine development proposals and received Mission COVID Suraksha (stimulus package) of Rs. 900 crores.

Funds Allocation & Expenditure by the Ministry of Health and Family Welfare

In the India's Union Budget 2021-22, the Ministry of Health and Family Welfare has been alloted Rs. 73,932 crores, with the Department of Health Research receiving 4% of the total amount. Funds are allocated to autonomous bodies such as ICMR, AIIMS and Post Graduate Institute in Medical Education and Research from the total amount. Though the allocation is 24% lower than the revised expenditure of 2019-20, funds allotted to ICMR have been drastically increased by 39%. Nonetheless, the Standing Committee on Health and Family Welfare finds the total allocation made to the Department of Health Research to be severely lacking, insufficient to match the necessities of research projects in the country (PRS Legislative Research, 2021).

DEPARTMENT OF SCIENCE AND TECHNOLOGY (DST)

About the Funding Agency

The Department of Science and Technology functions under the Ministry of Science and Technology. Recognising the need to promote Research and Development in emerging areas of Science and Technology in the Indian Innovation Ecosystem, the Department of Science and Technology was established in 1971. Its main responsibilities include the drafting of India's S&T policies, encouraging R&D activities in institutes and research laboratories and providing financial support schemes for the same.

The Department of Science and Technology has also set up three Technology Missions Divisions to promote research activities in specific thematic areas. These are - Technology Mission Programme on Clean Water and Clean Energy, Nano Science and Technology Mission and National Supercomputing Mission.

The following schemes have been studied in this review:

Schemes Studied [1]

1. Swarnajayanti Fellowship
2. INSPIRE Faculty Fellowship
3. Mission on Nano Science and Technology

Components

All the three initiatives provide selected scientists with a fellowship amount every month. Awardees of the INSPIRE Faculty Fellowship receive Rs. 1,25,000 per month as salary which is equivalent to the scale of an Assistant Professor at an IIT. This fellowship amount is discontinued in the event that the selected researcher attains a permanent position in the institute. On the contrary, the fellowship amount in the case of Swarnajayanti Fellowship is made in addition to the regular salary drawn from the employing institute.

INSPIRE Faculty Fellowship: The annual Research Grant of @ Rs.7 lakh every year (100%) including carry-forward amount, if any, from previous years shall be utilised for incurring expenditure under all recurring and nonrecurring budget heads like Manpower Cost, Consumables, Chemicals, Equipment. The amount under Travel 10% (i.e. Rs.70,000/- per year), Contingencies 10% (i.e. Rs.70,000/- per year) and Overhead Charges will be limited to 5% (i.e. Rs.35,000/- per year).

Application

Applications for Swarnajayanti Fellowship and INSPIRE Faculty Fellowship are invited annually. Applications for projects under Nano Mission are invited on a rolling basis. In the case of Swarnajayanti Fellowship and Nano Mission, applications can be directly made by candidates. Contrarily, INSPIRE Faculty Fellowship has established three methods of applying. First, researchers can directly send in their applications. Second, candidates can be nominated by their respective Heads of institutions, Directors or Vice Chancellors, along with Fellows of Academies in India and abroad. Third, IITs and IISc can shortlist and recommend candidates from their respective institutions, based on internal review.

Eligibility

Only Indian citizens who possess a PhD in the relevant disciplines can apply for the three funding initiatives. In case of INSPIRE Fellowship, the upper age limit is 32 years. It has been extended up to 35 years for candidates belonging to SC or ST groups. On the other hand, candidates between the age bracket of 30 to 40 years are eligible to apply for the Swarnajayanti Fellowship.

1. Information on the schemes studied:
   1. Swarnajayanti Fellowship
   2. INSPIRE Faculty Fellowship
   3. Mission on Nano Science and Technology

Selection Criteria

The quality of candidates' research proposals is a crucial factor that is common for all three schemes. Past academic performance of candidates and publications (at least 3) with high Impact Factor are two determinants, apart from the strength of research proposal and demonstration of independence in research, that determine selection of a candidate for the INSPIRE Faculty Fellowship. Candidates under INSPIRE Faculty Fellowship are selected by a three-tier selection process by - the Expert Committee by Indian National Science Academy (INSA), Apex Level Committee (INSA) and finally, the INSPIRE Faculty Award Council (DST). Based on these selection criteria, 1000 postdoctoral researchers are selected through contractual and tenure track positions.

Major Themes

The three funding initiatives differ in terms of thematic concentrations. The INSPIRE Faculty Fellowship funds scientists' research projects across all broad areas of Science. On the other hand, Swarnajayanti Fellowships are awarded to scientists for vital research projects in the realm of Science and Technology. The Nano Mission funds projects that specifically focus on the application of Nano Science and Technology towards greater understanding of basic research and S&T development.

Duration

Both INSPIRE Faculty and Swarnajayanti Fellowships are awarded to researchers for a duration of 5 years. Projects awarded under the Nano Mission are funded for a period of 3 to 5 years, depending on the nature of the project.

Institutions Funded

All the three initiatives have funded researchers at nodal IITs and IISERs and IISc Bangalore. However, out of the three schemes, AIIMS New Delhi's researchers are the sole All India Institute for Medical Sciences to have engaged with INSPIRE Faculty Fellowship. Furthermore, researchers in several sector-specific Higher Education Institutes have also received the INSPIRE Fellowship, such as - ICAR, Indian Agricultural Research Institute, New Delhi and Punjab Agricultural University. Swarnajayanti Fellowship has also been awarded to researchers at one sector-specific institute, the Tata Institute of Fundamental Research.

Other Schemes

Apart from these schemes, the Department of Science and Technology has also established the Science, Technology and Innovation Policy Fellowships Programme (DST-STI-PFP) to encourage technology studies, Science and Technology Innovation-related data and Monitoring and Evaluation in the field of Science and Technology Policy. It offers three varying categories of awards, namely STI-Senior Fellow, STI-Postdoctoral Fellow and STI-Young Policy Professional to promote engagement of researchers with India's Science and Technology ecosystem across different age groups.

In addition, the Department of Science and Technology also runs several schemes, such as the Fund for Improvement of S&T Infrastructure in Higher Educational Institutions (FIST) Program in order to contribute to the establishment of necessary research and development infrastructures in Higher Education Institutes and laboratories in India.

DEPARTMENT OF BIOTECHNOLOGY (DBT)

About the Funding Agency

The Department of Biotechnology functions under the Ministry of Science and Technology. Identifying the significance of biological sciences in the modern world, the Department of Biotechnology was established in 1986 to support the growth of basic research in India in the field of biological sciences. DBT has divided its 'Schemes and Programs' for Research and Development into four thematic areas:

1. Medical Biotechnology
2. Agriculture, Animal and Allied Sciences
3. Knowledge Generation & Research, New Tools and Technologies
4. Energy, Environment and Bio-Resource Based Applications.

Of these, the following schemes have been studied for this review:

Schemes Studied[2]

1. Ramalingaswami Re-Entry Fellowship
2. S Ramachandran - National Bioscience Award for Career Development
3. Har Gobind Khorana - Innovative Young Biotechnologist Award (IYBA)

Re-Entry Fellowship, nomination of a candidate can be submitted by a single host institute/university/industry only.

2. Information on the schemes studied:
   1. Ramalingaswami Re-Entry Fellowship
   2. S Ramachandran - National Bioscience Award for Career Development
   3. Har Gobind Khorana - Innovative Young Biotechnologist Award (IYBA)

Eligibility

Out of the three, two schemes i.e. Ramalingaswami Re-Entry Fellowship and S Ramachandran Award, are open for scientists up to the age of 45 years. The age restriction for IYBA is lower i.e. 35 years with age relaxation of 5 years for SC/ST/OBC, Women and Physically Handicapped candidates. Along with PhD, the applicants to all three schemes must have made significant contributions via their research and publications. Specifically, a candidate is eligible to apply for Ramalingaswami Re-Entry Fellowship only with at least 3 years of postdoctoral experience, of which overseas experience consists of 2 years.

Selection Criteria

Excellent academic career and significant background in research are some of the common selection criteria for the three schemes. Work experience of the past 5 years, made entirely in India, coupled with publications and patents, constitute as important determinants of the S Ramachandran Award and IYBA. Contrarily, selections under Ramalingaswami Re-Entry Fellowship are made on the basis of candidates' overseas experience and the strength of their research proposal.

Major Themes

The three schemes have provided financial support for fundamental research primarily in the field of Biotechnology and Bioscience, in line with DBT's mandate. The common subfields include: Biomedical, agricultural sciences and biotechnology.

Duration

IYBA and S Ramachandran Award are given to scientists for a period of 3 years. On the other hand, Ramalingaswami Re-Entry Fellowship funds projects for a duration of 5 years, with the possibility of further extension of 2 years.

Institutions Funded

Till date, several researchers at IITs, IISERs and AIIMS New Delhi have been funded by all the three DBT schemes under review. Funds from these three schemes have also been utilised at other institutions such as Indian Institute of Science, Bangalore and Institute of Nano Science and Technology.

Other Schemes

Apart from IYBA, S Ramachandran - National Bioscience Career Development Award and Ramalingaswami Re-Entry Fellowship, DBT also runs various schemes and awards to encourage high quality research in the Indian Science and Technology ecosystem. In particular, the M K Bhan - Young Researcher Fellowship Program provides independent research grants to young scientists for postdoctoral research work in the country, a scheme under the 'Building Capacities' initiative.

DBT has also created different spheres of schemes and programs, of which 'Research and Development' and 'Building Capacities' are two significant ones. Other categories include schemes for 'promotion of Biotechnology research in the Northeast Region' and programs for establishing biotech parks and incubators. In addition, DBT's 'Special Programmes' encourage research in biological sciences as a tool for societal development by coordinating with states and aspirational districts.

SCIENCE AND ENGINEERING RESEARCH BOARD (SERB)

About the Funding Agency

The statutory body was established by the Science and Engineering Research Board Act, 2008 to create a speedy system for providing financial and monitoring support to research projects and development of facilities. It funds relevant and quality research projects to fulfil the overarching aim of ensuring social and economic progress via scientific research. SERB has established the following three categories of research funding: 'Awards and Fellowships,' 'Schemes and Programs' and 'Partnership Programs'. The following schemes and fellowships have been considered in the study:

Schemes Studied [3]

1. Core Research Grant (CRG)
2. Ramanujan Fellowship
3. JC Bose Fellowship

Components

All the three schemes provide selected researchers with funds to cover overhead charges, equipment, manpower, travel and consumables, along with the research grant and regular income. Ramanujan Fellowship is the only scheme out of those studied that also provided for HRA within the monthly fellowship amount.

Application

The Core Research Grant and Ramanujan Fellowship are awarded annually to exceptional scientists while selections under the J C Bose Fellowship are made twice a year. Applicants need to be nominated by the heads of institutions or J C Bose Fellows.

Eligibility

Both CRG and J C Bose Fellowship necessitate applicants to hold a regular academic or research position in India at the time of nomination. On the other hand, Indian scientists are eligible to apply for the Ramanujan Fellowship only if they are below the age of 40 years and working abroad at the time of nomination. Furthermore, they will not remain eligible for the fellowship in case of their selection for a regular position in a university or institute.

Selection Criteria

SERB determines the suitability of applicants on the basis of the strength of the proposals submitted for review, competence of and contribution made by researchers and infrastructure available in the executing institutions. Specifically, all the three schemes lay emphasis on the stellar contributions made by Indian scientists. In the case of CRG, the Program Advisory Committee selects the researchers, while for J C Bose Fellowship, Search-cum-Selection Committee is the decision-making body.

Major Themes

Of the studied schemes, both J C Bose and Ramanujan Fellowship schemes fund projects belonging to all broad areas of science. SERB awards the Core Research Grant via eight established thematic divisions - Chemical Sciences, Earth and Atmospheric Sciences, Engineering Sciences, Mathematical Sciences, Life Sciences, Physical Sciences, Exponential Technology and Quantitative Social Sciences.

3. Information on the schemes studied:
   1. Core Research Grant (CRG)
   2. Ramanujan Fellowship
   3. JC Bose Fellowship

Duration

CRG funds research projects for the shortest duration i.e. 3 years. The JC Bose and the Ramanujan Fellowships provide financial support for a period of 5 years. Of these, extending the funding duration is possible only under the JC Bose Fellowship.

Institutions Funded

Till date, IITs and IISERs have been funded by all the three SERB schemes under review. Bathinda was the only All India Institute of Medical Sciences to have received funds under Core Research Grant. Funds from Ramanujan Fellowship have been utilised for research activities at several sector-specific HEIs such as Indian Institute of Nano Science, Indian Institute of Geomagnetism, Indian Statistical Institute and Indian Institute of Science, Bangalore.

Other Schemes

Apart from the Core Research Grant, Ramanujan and J C Bose Fellowships, SERB also runs various other schemes and awards. Some of these programs specially focus on promoting multi institutional research on pressing issues, such as the Intensification of Research in High Priority Area (IRHPA).

Moreover, SERB has also established specific awards, fellowships and grants to boost engagement of researchers belonging to certain groups. For instance, the Women Excellence Award and POWER (Promoting Opportunities for Women in Exploratory Research) are two such programs that aim to mitigate the gender disparity in Science and Technology research funding.

Furthermore, SERB also provides financial support to facilitate research by extending grants for international travel support during research presentations and organising seminars.

INDIAN COUNCIL OF MEDICAL RESEARCH (ICMR)

About the funding agency

The Indian Council of Medical Research is the topmost body in India for conception, coordination and promotion of biomedical research in the country. Established in the pre-independence era, ICMR is one of the oldest medical research institutes in the world. It strives to establish programs that encourage innovation which can be implemented in the public health system in the long term.

These initiatives are shaped around the following seven thrust areas: Communicable Diseases, Tribal Health, Reproductive and Child Health, Nutrition, Non-Communicable Diseases, Basic Medical Sciences and Traditional Medicine. In particular, ICMR awards several Senior Research Fellowships and Junior Research Fellowship/Research Associate on the basis of UGC-NET score to promote medical research.

The following schemes have been evaluated as a part of this study.

Schemes Studied [4]

1. Ad-hoc Project Funding
2. Emeritus Scientist Scheme
3. Cohort Studies

Components

All the three initiatives differ in terms of the amount allotted for research. The Emeritus Scientist Scheme provides a Honorarium of Rs. 1,00,000/month. Under Ad-Hoc Project funding, researchers get a maximum of Rs. 1.5 crore for the entire duration of the grant. Contrarily, researchers involved in Cohort Studies receive Rs. 2 crore per year. Researchers involved in the Ad-Hoc Project Funding and Cohort Studies provide for travel and contingency grants as well, further covering for equipment and overhead charges. On the contrary, the Emeritus Scientist Scheme does not provide for contingency funds, but gives Pension/Provident Fund to the selected scientists.

Application

Applications under the ICMR-Emeritus Scientist Scheme can be made on a rolling basis. The same are considered in two batches: applications sent from January to June are evaluated in July, while those sent between July and December are evaluated in January. On the other hand, calls for proposals under Ad-Hoc Projects and Cohort Studies are advertised online for scientists' perusal.

Eligibility

The ICMR-Emeritus Scientist Scheme is available for researchers who have retired/are about to retire from a permanent position in a University. As such, the minimum age criterion for eligibility is 60 years under this scheme. On the contrary, for Ad-Hoc project funding, scientists must hold regular employment in a Medical college/Research Institute or Laboratory or a registered Semi-Governmental institute.

Selection Criteria

Selections under the ICMR-Emeritus Scientist Scheme are made on the basis of candidates' contribution and engagement with biomedical research.

4. Information on the schemes studied:
   1. Ad-hoc Project Funding
   2. Emeritus Scientist Scheme
   3. Cohort Studies

Major Themes

All the three initiatives fund research in fields of biomedical research.

Duration

Both ICMR-Emeritus Scientist Scheme and Ad-Hoc Project funding provide financial support for 3 years, with the possibility of extension up till 5 years. However, the former is renewed each year. The Cohort Study projects are provided funds for a duration of 5 years with the possibility of extension.

Institutions Funded

Scientists who belonged to AIIMS New Delhi and IISc Bangalore have received funding under this scheme.

Other Schemes

Apart from the schemes evaluated above, ICMR has also established different categories of projects to promote research in specific thematic areas. For instance, Task Force Studies are nationally coordinated projects wherein scientists across the country collaborate on time-bound and specific objective-oriented projects of national interest. Similarly, the National Registry maintains a systematic framework to collect clinical and non-clinical data on disease control.

The Indian Council of Medical Research also aims to encourage research practices among undergraduate students by awarding Short Term Studentships each year. In addition, ICMR also invites proposals for establishment of Centres of Advanced Research (CAR) to promote research on a particular subfield of medicine. The scheme entails development of Research and Development facilities, centred around an eminent scientist. One objective behind this is to assist the selected scientists in expanding upon their work. Secondly, the parent institutions are expected to take over control and maintenance of the infrastructure to ensure it can be utilised by multiple researchers for long periods. The emphasis laid on stimulating long term impact that is not restricted to the field of medical research alone is a key feature of ICMR schemes.

COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH (CSIR)

About the Funding Agency

The Council of Scientific & Industrial Research (CSIR) funds R&D activities to promote innovation and progress in diverse S&T fields such as oceanography, geophysics, chemicals and biotechnology. Its main objective is to assist projects with potential for scientific and societal impact that leads to economic development. It lays special emphasis on converting fundamental research into value-added technologies that boost collaboration among stakeholders from HEIs and within the industry.

CSIR has established 8 Theme Directorates to target particular projects and problems in specific sectors of STEM research as under:

- Aerospace, Electronics, Instrumentation & Strategic Sector
- Civil Infrastructure and Engineering
- Mining, Minerals, Metals and Materials
- Energy (Conventional and Non-Conventional) and Energy Devices
- Chemicals and Petrochemicals
- Ecology, Environment, Earth and Ocean Sciences and Water
- Agri, Nutrition and Biotech
- Healthcare

With such provisions and policies, CSIR plays an influential role in S&T human resource development via its fellowships and grants for research projects and specific schemes that encourage research enthusiasts and young scientists to pursue doctoral and postdoctoral research. In particular, CSIR's Shanti Swarup Bhatnagar Prize recognises and awards exceptional scientists and their contributions to the field.

Schemes Studied [5]

1. Shanti Swarup Bhatnagar Prize (SSB)
2. Emeritus Scientist Scheme

Components

Researchers selected for the SSB Prize are awarded Rs. 5,00,000. Further, they receive Rs. 15,000 per month honorarium up to the age of 65 years. Under the ES scheme, selected scientists are offered a monthly allowance of Rs. 20,000 for the duration of the award. It also provides funds to the selected researchers for purchase of equipment, housing and medical allowances and contingency expenditures. Further, the grant also partially covers expenditure for foreign travel - up to Rs. 30,000 or 50% of the air fare (whichever is less). Researchers' awards will be withdrawn if the applicant accepts any other fellowship or employment.

Application

Applications under the ES scheme can be made at any given time of the year. The same can be submitted by the host institution's executive authority. Further, the offer of Emeritus Scientistship is valid for one year from the date of receipt of selection letter. Similarly, researchers can apply for the SSB Prize only if they are nominated by a member of the CSIR Governing Body, executive authorities in Universities, Institutes of National Importance or major research organisations.

Eligibility

Researchers up to 45 years of age are eligible to apply for the SSB prize. Under the Emeritus Scientist Scheme, researchers are eligible to receive funding for the grant duration until they attain the age of 65 years. However, this age limit under the ES scheme is not applicable

5. Information on the schemes studied:
   1. Shanti Swarup Bhatnagar Prize
   2. Emeritus Scientist Scheme

for SSB winners, Fellows of INSA, Indian Academy of Sciences, NSAI and INAE.

Selection Criteria

The SSB prize is awarded to researchers on the basis of their contribution to the field of STEM research. Selection process of the ES scheme focuses on scientific work undertaken by applicants in the 5 years preceding the year of application and any grants or honors awarded to them. Selection is made by the Standing Committee that meets twice a year.

Major Themes

Awards under both the streams are made under the broad areas of science and technological research - Biological Sciences, Chemical sciences, Earth, Atmosphere, Ocean and Planetary Sciences, Engineering Sciences, Mathematical Sciences, Medical Sciences and Physical Sciences.

Duration

SSB Prize is awarded annually while ES scheme is awarded for a duration of three years. A detailed evaluation of the project is conducted two-and-half years into the funding to determine if an extension can be awarded until researchers attain the age of 65 years. In case of SSB winners and Fellows of INSA, Indian Academy of Sciences, NSAI and INAE, the scheme is applicable for 5 years on two conditions. Firstly, an Emeritus scientist's age must not exceed 70 years during the period. Secondly, CSIR should receive a favourable recommendation from the director/vice chancellor of the host institution.

Institutions Funded

Scientists from prominent IITs such as Bombay and Kharagpur, IISER Pune and IISc Bangalore have been awarded under these schemes for their remarkable contribution to the field.

Other Schemes

CSIR has also established several other schemes to promote STEM research at the intersection of academia and industry. Further, it also awards Junior and Senior Research fellowships and research associateships to young researchers to inculcate an interest and the requisite skills for research work in the field. Similarly, the CSIR-Nehru Science Postdoctoral Research Fellowship Scheme recognises novel project ideas among young researchers and provides them intensive training in different areas of basic sciences. The organisation also awards Bhatnagar Fellowships to prominent scientists with outstanding contributions to the field. Apart from these, it also offers travel and Symposia grants to foster collaborations among researchers from various institutions and organisations.

In a Nutshell

The processes adopted by India's agencies to fund STEM research share some common elements that reflect the country's larger outlook towards the R&D ecosystem.

Many schemes have laid emphasis on eligibility criteria for researchers that are clearly expressed in most grant notifications.

Out of all the schemes studied, very few programs and agencies provided detailed information and guidelines on the grant filing procedure to interested applicants.

The process to apply for grants under these programs is marred by gaps in details on indirect costs and the time taken for the selection process to be completed, among many other necessary details.

In addition, applicants often do not receive feedback/ reasons for rejection of their proposals, which in turn leaves them unprepared for future applications. In many other countries, including those studied in the next section, the opposite scenario is true. An established and standardised system to ensure that details of proposal review are shared transparently with applicants is beneficial on two levels. First, it would enable researchers to draft better proposals for upcoming grant applications. Second, it would also enhance the overall R&D standards in the STI ecosystem in India while instituting confidence in the fruitfulness of R&D pursuits in the STEM spaces in India.

India vs International Models

**Refer to Appendix B for tabulated data on the charts in this section*

Comparison of R&D Statistics

Purchasing Power Parity (PPP) is an internationally preferred way of comparing and calculating cross-country R&D statistics and is widely used by organisations such as OECD. While calculating the share of academic research in national statistics of R&D expenditure, most countries include only the research component of block grants provided to universities. These block grants are also referred to as General University Fund (GUF), considering contributions by federal and state/provincial governments. This practice tends to understate the actual R&D expenditure made by governments in academic research since it does not account for the specific project-based research grants; thus making it difficult to make international comparisons. However, given that the GUF accounts for almost 30-50% of the government's expenditure in academic R&D for various countries such as the UK, France and Germany, it provides important insights about patterns of academic funding worldwide (NSF 2018).

The OECD publishes annual statistics on government R&D investment to highlight how national R&D priorities vary between nations. This index, formally known as Government Budget Allocations for R&D (GBARD), reveals how government R&D funding in various countries is distributed across a broad range of socio-economic categories such as Defence, Economic development programs, Health and Environment, Education, Civil space, and General university funds (NSF 2018). Notably, defence remains the topmost priority for government R&D investment in several countries, with the US having the highest federal Defence R&D funding at 51% (2015), followed by the UK at 16%, South Korea 14%, France 7%, and Germany and Japan at 3-4% (Ibid). The GBARD data for China and India is currently unavailable.

Top R&D Performing Countries

(by share in global R&D)

The USA and China are top R&D performing countries, accounting for **25%** and **23%** of the global R&D expenditure respectively. Japan and Germany's R&D expenditure account for **8%** and **6%** of the global total respectively. These are followed by India **(2.3%)**, the UK **(2.27%)** and other countries in the **2%-3%** bracket (Boroush 2020).

The gross domestic expenditures on R&D as a part of its GDP is the highest in South Korea **(4.6%)**, followed by Israel **(4.5%)**.

Asia contributes the largest lump sum amount of R&D expenditure (995.45 billion PPP $) (chart 2) and also has the largest % share in World GDP (45.41%); however, it lags behind in the GERD—R&D Expenditure as % GDP statistic (1.6%) (chart 1). As per a report by NSF, Northern America, Europe and Oceania occupy the top three positions in GERD as per continent-wise consolidated data with Asia only coming in on the fourth position despite its large lump sum contribution (chart 1).

There is more to the Asia story. In 2015, South Asia accounted for only 2.8% of the Global R&D expenditure whereas East & Southeast Asia accounted for 37.6%. This may be attributed to the high expenditure made by Japan, China and South Korea among the various countries of the East & South East asian region (NSF 2018). In 2017, the gap widened as East & SouthEast Asia contributed 39.2% and South Asia contributed a mere 2.5% to the global R&D expenditure total of 2.153 trillion PPP $ (NSF 2020).

Chart 1

R&D Expenditure as % GDP by Continents

(Source: NSF. Science & Engineering Indicators 2018)

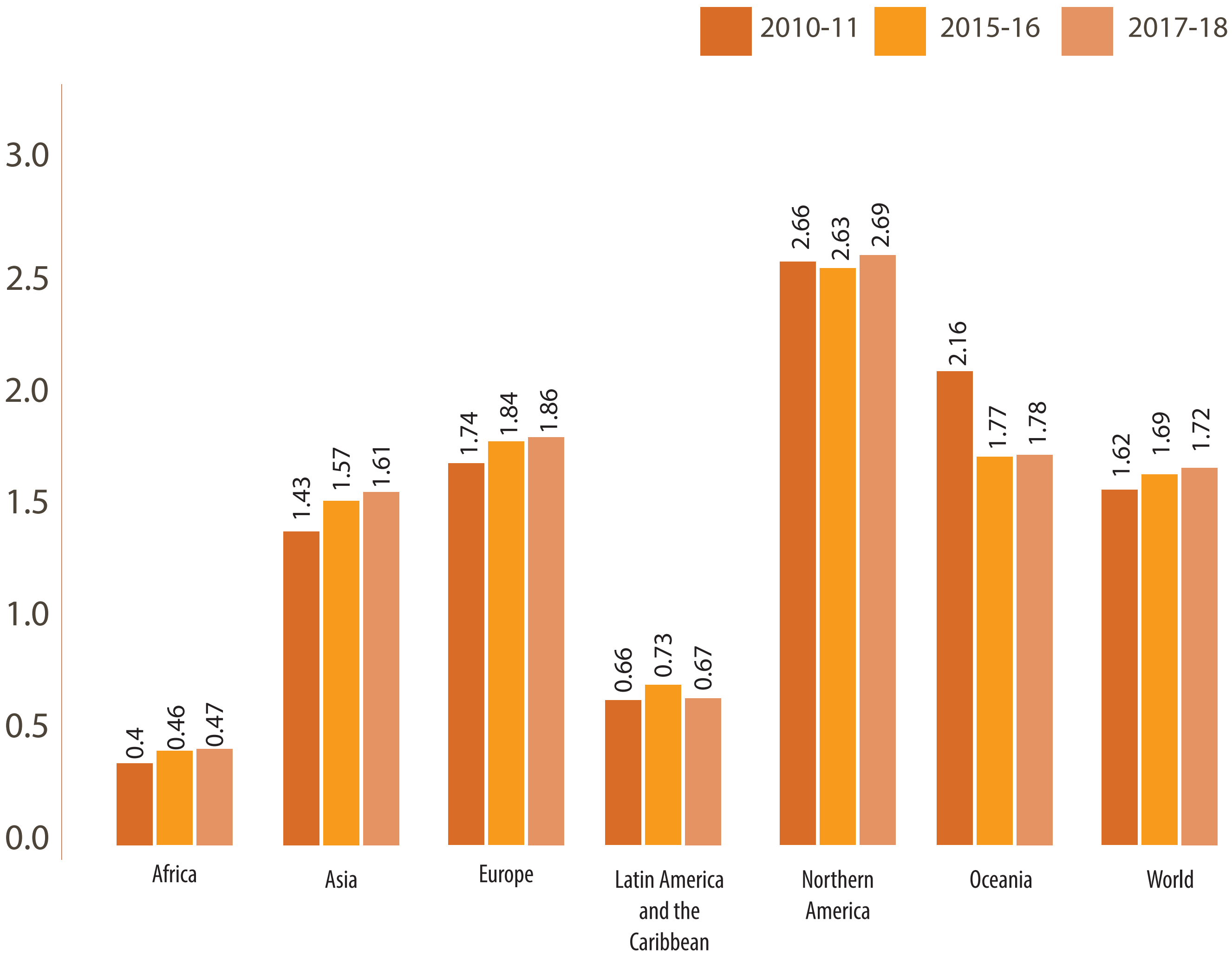


Chart 2

Expenditure on R&D by Continents (billion PPP $)

(Source: NSF. Science & Engineering Indicators 2018)

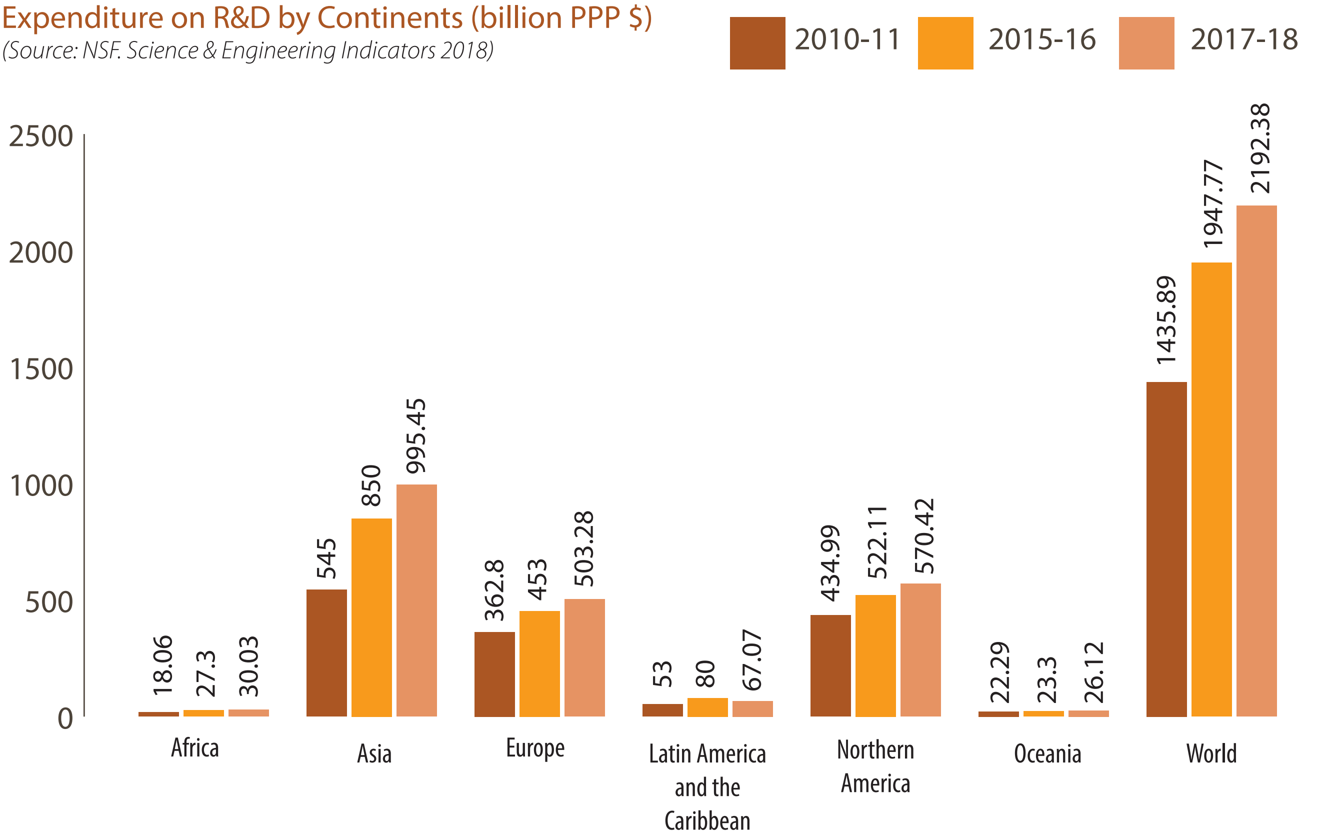
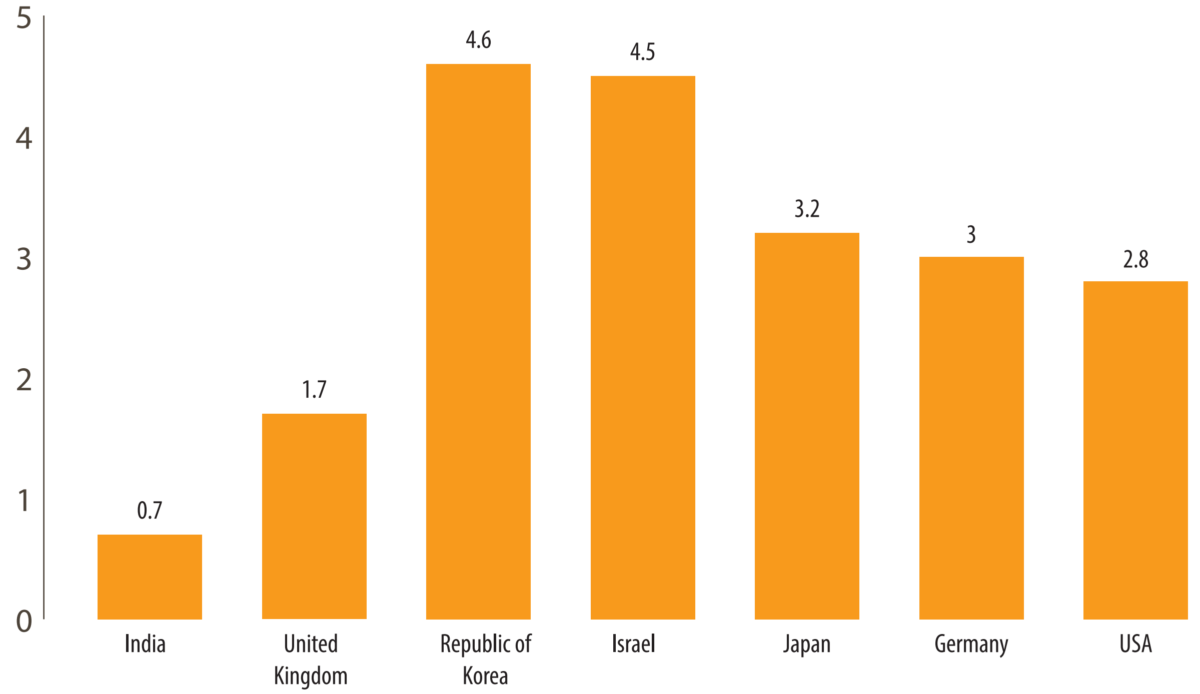


Chart 3

Country-wise GERD (Expenditure on R&D as % GDP)

(Source: NSF. Science & Engineering Indicators 2018)

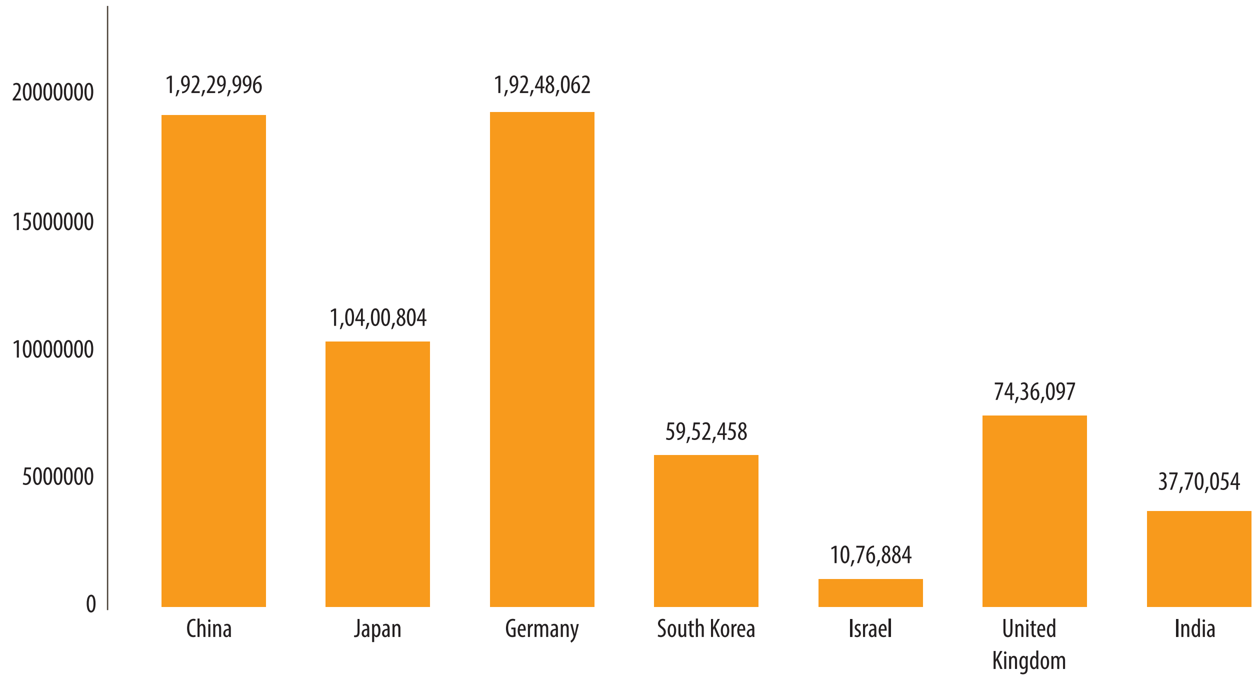


Out of all the countries studied as part of this report, India has the lowest GERD (0.7%) which is drastically lower than what it has been aiming to achieve since the last three decades (2%). Some of the countries with a lower GERD than India include Mexico (0.5%), Venezuela (0.3%), Pakistan (0.2%), Sri Lanka (0.1%). South Korea and Israel are the countries with the highest GERD in the world, of 4.6% and 4.5% respectively. Chart 3 highlights the drastic difference in India's expenditure on R&D as compared to the top economies known for their contribution to STEM.

Statistics show that India needs to diversify its contribution to the GERD statistic via private and higher education sectors that currently spend way less than the government.

Chart 4

GERD performed by Higher Education - funded by Government (in 1000 current PPP $)
(Source: UIS UNESCO)



The chart above (chart 4) particularly shows GERD performed by higher education institutions, funded by the Government (in 1000 PPP $) across nations. It highlights the lack of R&D expenditure in the HEIs of India (by the government), in comparison to the scenario in all other countries studied (except Israel). Despite Israel's high GERD of 4.5%, it has the lowest statistic for GERD performed by HEIs, funded by the government, which is characterised by the high contribution of its business sector in the GERD.

Figure 1

Top STEM R&D Higher Education Institutions Across Countries

TOP STEM R&D HEIs

CHINA
- Tsinghua University
- Zhejiang University
- Shanghai Jiao Tong University

GERMANY
- Freie University
- Humboldt University
- University of Bonn

INDIA
- IIT Madras
- IIT Bombay
- IIT Kharagpur
- IIT Delhi

ISRAEL
- Hebrew University
- Tel Aviv University
- Weizmann Institute

JAPAN
- University of Tokyo
- Kyoto University
- Osaka University

SOUTH KOREA
- Seoul National University
- Yonsei University
- Korea University

UNITED KINGDOM
- University of Oxford
- University of Cambridge
- University College London

USA
- John Hopkins University
- U. Michigan
- U. Washington
- Stanford University

Figure 2

Top National Research Funding Agencies Across Countries

CHINA
- National S&T Mega Projects
- National Key R&D Program
- National Natural Science Foundation

GERMANY
- DFG
- DAAD
- DFG
- Alexander von Humboldt Foundation

INDIA
- DST
- DBT
- CSIR
- SERB
- ICMR

ISRAEL
- TELEM
- Israel Science Foundation

JAPAN
- Ministry of Education, Culture, Sports, Science & Technology

SOUTH KOREA
- National Research Foundation (NRF)
- MSIT
- MOE

UK RESEARCH COUNCILS
- Biotechnology & Biological Sciences
- Engineering & Physical Sciences

USA
- National Institutes of Health
- Department of Health and Human Services
- National Science Foundation

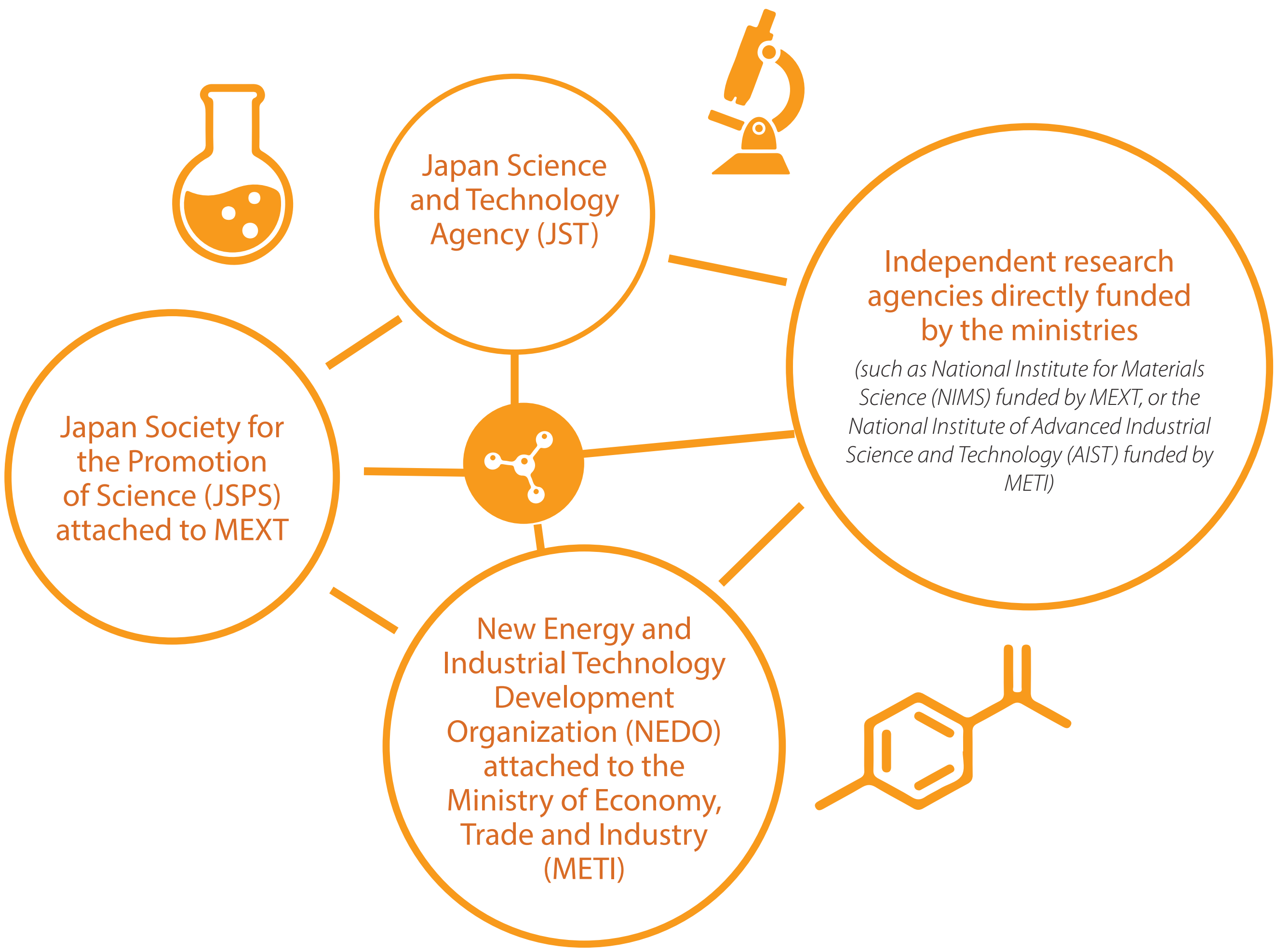
Overview of Research Funding Models Across Nations

Japan

The Science, Technology and Innovation (STI) system of the Japanese R&D funding largely has the three-tiers:

Council for Science and Technology Policy (CSTP) is the entity responsible for planning and coordination of research policy for the country. However the implementation of these policies and the distribution of research funding is made by individual ministries, the largest government R&D expenditure being done by the Ministry of Education, Culture, Sports, Science and Technology (MEXT). The last tier consisting of Independent Administrative Institutions (IAIs) looks after the operative and administrative level of research funding. These IAIs support researchers in Japan by running their own or coordinated programs, including some in collaboration with other countries.

The Independent Administrative Institutions (IAIs) have the following major funding bodies:



In 2004, the 'Corporatisation of National Universities' reform gave an independent corporate status to Japan's national universities thus providing them with autonomy over managing its operations and allowing larger integration of teaching and research (Maruyama 2007).

The shift "from institutional to individual aid" and "from basic grants to competitive and project-based grants" are said to be two of the recent trends in research public funding in Japan. Therefore the Japanese government appears to be moving away from institutional aid such as core/operational grants and instead towards grants given directly to researchers. The Japanese government also emphasised on a 'selection and concentration' strategy for allocating funds to specific research fields, researchers and institutions. Though this trend has benefited research-oriented HEIs and specific study fields, the researchers now have to spend significant amounts of time on preparing reports and doing peer-review for research proposals (Ibid).

USA

As per a report by the National Science Foundation of USA, the federal government of the country prefers to fund specific projects that are separately budgeted instead of providing general university funds (block grants) (NSF 2018).

In the USA, STEM Research is classified into three groups: Basic Research, Applied Research and Development. Information generated from Basic Research is expanded for practical use in Applied Research and structured into technology for development purposes. Federal expenditure on R&D increased from $2.8 billion in 1953 to $127.2 billion in 2018. However, since 2011, it has been on a decline, reduced by 9% in the Presidential Budget for FY2021 (Mandt, Seetharam, and Cheng 2020).

Private corporations predominantly fund applied research, although they rely more on basic research conducted at universities. Almost 90% of articles in the Nature Index by corporations were written in collaboration with university-based and government lab researchers (Nature 2017).

The National Science Foundation is the foremost funding organisation in the country for exploring scientific discovery and progress. Other organisations include the Department of Defence, Department of Energy, and Department of Health and Human Services. 60% of the funds from these agencies are allocated to researchers in universities conducting basic research (Mandt, Seetharam, and Cheng 2020).

The USA's STI ecosystem in HEIs receives funds from different sources such as the federal, state and local governments, intramural grants and private sector. Of this, the federal government provides 53% of the total funds while state and local governments contribute 5.4%. Internal funds of institutes contribute to 25.2% of the total expenditure and private sector's input to R&D in academic institutions is very low at 6% (National Science Board 2018).

Due to its restrictive understanding of Basic and Applied Research, there has been a lack of private expenditure for the former, undertaken mostly at HEIs. The changing dynamics surrounding public and private expenditures on STEM research in the USA is reflected in its performance on different indices. For example, though the country holds its position as the leading spender in public and private R&D expenditure combined, its share of global R&D has fallen from 69% during the post-World War II era to 27.7% in 2017 (Mandt, Seetharam, and Cheng 2020).

United Kingdom

In the UK, there are three main sources of receiving government funding for R&D:

1. Block grants that are allocated to HEIs by Funding Councils
2. Research grants made by the Seven Research Councils of UK
3. R&D Spending by individual government departments

The UK's STI research ecosystem follows a 'Dual Funding Structure' to assess, monitor and encourage research in the country (Hughes et al. 2013). Under this, universities can receive public funds from two major sources: funding councils and research councils. The latter provide funds for particular research projects based on a competitive application process.

Between 1995 and 2011, the UK's annual R&D spending rose by 37% while the contributions made by public research institutions to R&D fell by 19%. In 2019, the Business sector funded 67% of R&D, government funds contributed to 7% of the total funds while HEIs contributed 24%. Of the private sector expenditure, around 44% of it is made only by the top ten businesses in the UK with the pharmaceuticals sector being the major recipient of a quarter of the funds (National Audit Office 2013).

Among the Research Councils, Engineering and Physical Sciences Research council, Biotechnology and Biological sciences research council, Medical Research Council are prominent funders of STEM research. Apart from this, the National Academies - Royal Society, British Academy, Royal Academy of Engineering and Academy of Medical Sciences are also some key funding agencies.

The Innovation and Research Strategy for Growth in the UK focuses on monitoring the country's performance with the help of two indicators of research outputs and business innovation - UK's share of the top 1% of cited research and levels of Business Investment in R&D.

HEIs contributed to 27% of total R&D which is way higher than the OECD average of 19%. According to UK Research and Innovation, growth in R&D undertaken in the UK is at similar levels with other countries but the latter have increased their expenditure at a faster rate than the UK. The national government aims to increase the total R&D expenditure to 2.4% of the country's GDP by 2027 (Rhodes, Hutton, and Ward 2021).

South Korea

In 2009, the National Research Foundation (NRF) of South Korea was established as a result of the integration of three bodies: Korea Science and Engineering Foundation (KOSEF), Korea Foundation for International Cooperation of Science and Technology (KICOS) and Korea Research Foundation (KRF). The foundation is responsible for planning, managing and evaluating the research and academic activities of industry, research institutes and universities of the country.

In line with the postwar focus on applied research, South Korea's R&D funding has traditionally been top-down and aimed at boosting competitiveness in specific fields of research through 'government-directed projects', often in collaboration with the private sector. However, recent trends show that the focus is now shifting towards basic research funding as well as an increased emphasis on bottom-up research funding. As per reports, direct funding of basic research to principal investigators (PIs) has levelled up to match the funding made to mission-oriented top-down projects. NRF grants are believed to be largely responsible for this shift.

The programs of Korea's NRF are categorised as

» Basic Research in Engineering and Science
» Academic Research
» Humanities & Social Sciences
» International Cooperation
» National Strategic R&D programs.

In the total budget of NRF (USD 6.427 billion for FY2020) Academic Research & University Funding comprises 32.2% and Basic Research in Science and Engineering comprises 29.0% of it (NRF 2021).

NRF's Directorate for Basic Research in Science & Engineering has programs lucidly categorised on the basis of 'Individual Research', 'Group Research', 'Infrastructure Building', and 'Fostering the Next Generation of Researchers'.

China

In January 2015, the State Council of China released a notice regarding the management reforms for the Central Fiscal Science and Technology plan of the country. Through this notice, the country's 100+ national-level STI programs were combined into five types of plans/pillars:

» National Natural Science Foundation of China
» National S&T Mega Projects
» National Key R&D Program
» Technology Innovation Guidance Fund and Bases
» Bases and Talents Program

Of these five plans/pillars, the first three provide research funding. Whereas, the fourth and the fifth pillars support 'commercialisation & technology transfer' and 'provide support to extraordinary researchers and teams by providing subsidies and priority for other research programs', respectively (Notice of the State Council on deepening the management reform plan of the central fiscal science and technology plan 2021).

Following the above-mentioned reform, the implementation for most research plans on a national level in China are done through convening of an inter-ministerial joint committee by the Ministry of Science and Technology (MoST). The joint committee includes representatives from the Ministry of Finance (MoF) and the National Development and Reform Commission (NDRC), as well as other relevant commissions and ministries. This committee is responsible for setting up specific research programs that are to be led by a host organisation. The host organisation supports in specifying budget plans and fields of research. This could be a government agency in charge of the concerned field (typically the Ministry of Science and Technology) or a research foundation sponsored by the government. An expert committee called the 'Strategic Consultation and Comprehensive Review Committee' is also set up to provide professional insights to the inter-ministerial joint committee.

China has been running several programs for research in HEIs of the country. Project 211, Project 985 and the C9 League was created by the country in the 1990s with the aim of raising its universities to an elite and international level standard. The C9 league particularly included 9 universities selected for a funding period of 3 years. Other programs such as the 863 Program (State High-Tech Development Plan) have also now expanded their scope, upon revision, to include more technological fields to focus on (National High-tech R&D Program (863 Program) 2021). The famous Changjiang (Yangtze River) Scholars program enhanced professors' pay significantly and led to the luring of excellent researchers and professors from small & poor to leading Chinese universities, to the extent that the government had to release a set of rules barring the top universities from doing so. This new set of rules was released in 2017 with the aim of encouraging top universities to hire overseas researchers rather than exhausting each other's pool of intellectuals (Jia 2017).

Made in China 2025 (MIC 2025) is the latest techno-strategic ambition of the country that aims to make Chinese companies self-reliant and become global leaders in high-tech industries. In short, the MIC 2025 is aimed at making China "self-sufficient" and a "manufacturing superpower" as part of its overall agenda of "innovation-driven development" (Kania, 2019).

Germany

In Germany, the private sector is the main investor in the R&D ecosystem, contributing to 68% of total funding in 2019. Of this, the automotive industry is a key recipient of these funds. Apart from this, publicly-financed non-university research organisations commit over 16 billion USD annually, positioning non-university institutes as prominent players in the ecosystem. In Germany's HEIs landscape, funds are raised for basic research, applications-oriented research and collaborative projects with companies and research institutes. The responsibilities of public research funding in Germany is shared between the federal government and the individual states. The Ministry of Education and Research provides funds to HEIs for the promotion of research and innovation on diverse themes under STEM and humanities. The Deutsche Forschungsgemeinschaft (DFG), the German Research Foundation, is among the main funding agencies of Germany that funds high impact, individual projects by researchers at HEIs and non-university institutes.

The High-Tech Strategy 2025 focuses on products and services, builds international networks and prioritises research themes. The Excellence Strategy is a commission of international experts to decide on the distribution of funds among excellence clusters and universities. The Internationalisation Strategy emphasises on cross-country collaborations for education, science and research (Federal Ministry of Education and Research).

As a result of consistent efforts in the HEI space, Germany is the third most prolific country in the Nature Index, after the US and China, for research output in the 82-high quality natural sciences journals. Further, it has received the reputation of opportunity 'blue-sky research' i.e. research projects with little to no immediate practical applications (Boytchev 2020). As a result, it funds projects that may face difficulties in securing government funding elsewhere.

Further, the country's research performance has been phenomenal in both traditional as well as newer subfields of science and technology such as sustainability science (Boytchev 2020). Germany has set the goal of increasing R&D spending to 3.5% of its GDP by 2025.

Israel

In Israel, major R&D activities are undertaken at seven universities, numerous government and public research institutes, medical centres, public service firms and civilian and military enterprises. The government and public bodies constitute the primary sources of R&D funds in the country, contributing to over 50% of the R&D activities. In 2018, Israel's expenditure on research accounted for 4.94% of its GDP. In Israel, funds are allocated majorly for industrial and agricultural sectors, keeping into consideration the overall objective of economic development (Ministry of Foreign Affairs).

Israel Science Foundation is the key funding agency for competitive basic research funding in the country. Almost 80% of all publishable research, predominantly fundamental research, is undertaken in Israel's academic institutions (Ministry of Foreign Affairs).

A key characteristic of Israel's STEM ecosystem in HEIs is the presence of Science-based industrial parks. These were first established by the Weizmann Institute of Science to translate basic research for some commercial use. Such parks are established near university campuses, along with spin-off industrial firms that can utilise research outputs for commercial reasons.

A major outcome of these institutions is that Israel publishes about 1% of the world's scientific publications, with a large number of authors in natural sciences, engineering, agriculture and medicine. It has the fifth highest number of scientific articles per million population. The country's funding model leads the world in showing the advantages of close collaborations between public and private sector, and the role played by the government in enhancing the overall innovation standards in the ecosystem.

Uncovering Research Funding

This section will look at decluttering various aspects of research funding across the chosen countries with the view to derive lessons and tips for India in designing the future policies. The seemingly innocuous headers of the sections hold within them important insights and clues as to the reason for why some countries have been so successful while India has not made the mark in the STEM R&D space.

In the section below, we will look at the criteria such as components of grants, the eligibility and selection criteria, the feedback mechanism, the duration of the grant and the autonomy in grant expensing

1. Components of Grants

Budget formulation is an important and intrinsic element of research proposals submitted to seek funding. Most countries require a distinct tally of expected direct and indirect costs. Direct costs in a research project refer to expenditure that is directly incurred by applicants while undertaking research on the proposed topic. Some common examples of direct costs include expenditure on publications, salaries of personnel involved and material and supplies. On the other hand, indirect costs can be divided into two categories: institutional costs and administrative costs. STEM research requires well-developed infrastructure in host organisations. Charges levied by universities for the use of research facilities form a major part of the indirect costs. Other expenditures include costs of undertaking administrative functions such as budget monitoring and review of the project.

Since the direct costs involved in a research project from the Science and Technology field are similar in nature, our study observed that direct costs covered under grants by the seven countries (and India) remain more or less similar. These include - salaries of personnel, travel allowances, publication costs and expenditures for purchase of equipment. However, variations can be observed in the terms of grants for indirect costs.

1a. Calculating Indirect Costs

Unlike India, most of the countries under consideration have predetermined rates of indirect costs that can be charged by a university and requested for in applicants' budget proposals.

In Japan, the amount awarded for overhead charges is equivalent to 30% of the requested direct costs. In Israel, the rate is fixed at 17%.

In the USA, there are different levels of indirect cost rates that have been negotiated on the basis of the nature of research conducted and the host universities. In 1991, the maximum amount-rate that can be requested was fixed at 26%.

In a somewhat unique case, the UK's research councils employ the Transparent Approach to Costing (TRAC). Under this, universities measure their indirect costs rates by following a uniform methodology. Their calculations are further verified by UKRI councils.

As a mark of the comprehensive nature of these systems, certain provisions have been established in case universities and organisations do not have a negotiated indirect costs rate. In the USA, researchers belonging to HEIs without a predetermined rate are required to submit a budget proposal specifically outlining the indirect costs based on the previous fiscal year's expenditures, made by their university's business officer. In the UK, the research councils have adopted 'dispensation default rates' for universities and organisations whose methodologies are under review and awaiting verification.

All the above examples point to the adoption of a standardised approach for each country, except in the case of India.

1b.Modifications to Requested Indirect Costs

In countries such as South Korea and the USA, certain restrictions are levied on reporting indirect costs during the proposal stage. In the event that the negotiated indirect costs rate changes for the university/researcher, the funding agencies will not cover the difference.

1c. Cost of Equipment

In addition, though the studied agencies and countries cover purchase of/expenditure on equipment, they also levy numerous restrictions. USA's NSF includes expenditures on only those equipment covered that have a 'useful life' of more than one year and 'acquisition cost' equal to or more than $5,000 per unit (NSF 2005). In the UK, researchers can include equipment costing over 10,000 pounds in their proposals only with additional justifications.

The study also discovered some exceptional cases that highlight important lessons for India. At this point, the lack of clarity in the Indian funding agencies' on the type of indirect costs covered in grants causes confusion and ambiguity for researchers during the grant filing process. China represents an extreme version of this where very minimal data is available on all costs covered by the grants. Provisions of their grants are more subjective and often undisclosed.

Going beyond the lack of information, the components of direct and indirect costs are also crucial. Germany has proved to be a unique country where some schemes provide even child care and stipend for supporting researchers' dependents. Such well-intended and executed provisions encourage young scientists and aspiring researchers to enter the field of fundamental research and enable them to focus on conducting groundbreaking research. Further, with assistance from funding agencies and their host organisations, researchers would not have to worry about the financial and administrative responsibilities attached to the project. In order to improve the quality of STEM research conducted in India and to make it more inclusive and diverse, emphasising on these aspects and creating a natural place for accommodating their inclusion as part of standard operating procedure for grant funding is important.

Key Highlights

- 4 out of the 7 countries studied have implemented a framework to incorporate fixed indirect cost rates in project grants. A similar uniform system in India can potentially provide adequate information to researchers which may contribute to more accurate budget proposals.
- Given the vast numbers of universities undertaking research in India, a system akin to the UK's TRAC could be adopted where HEIs with non-negotiated rates followed a default, government-defined rate of charging indirect costs.
- The German example leads the way in terms of opening the haloed STEM corridors to benefit from greater participation of women in STEM research, through inclusion of child care support. For a country with a healthy gender balance within its demographic dividend, this is a valuable aspect to consider.

2. Eligibility criteria: Who can apply?

Age and gender are some of the common eligibility criteria for specific programs that target young researchers, senior researchers or women researchers of the country. Educational qualifications such as PhD, MD, post doctoral degrees also feature as a common requirement in several programs across nations.

Work experience in general or particularly scientific work in a related/unrelated field is often required as an eligibility criterion for certain awards in India, Israel and Germany. India's Janaki Ammal- National Women Bioscientist Award is one of the examples of an award that requires outstanding contribution acknowledged by publications & made entirely in India in the last 5 years to be eligible. Whereas, fellowships such as the Ramalingaswami Re-entry Fellowship are entirely catering to the Indian research community working abroad and seeking to re-enter India's research ecosystem.

The eligibility criterion of currently holding a research or academic position at an educational/research institution in the country is also commonly observed across several schemes/programs that fund research in higher education.

Several countries have awards which require nomination from the host institution of the researcher in order to be considered eligible for the funding program. For example, India's JC Bose Fellowship and Shanti Swarup Bhatnagar award require researchers' host institution/universities to nominate the researcher for the award. In the case of China, a host organisation typically proposes project budgets and new research projects to a joint committee. It also formulates the criteria to be met by the researchers and/or research institutes to be eligible to apply for the concerned project funding. Following the advice from an expert committee, the joint committee then approves the proposal. Lastly, eligibility criteria is also often reviewed as part of the initial steps of the selection review.

Key Highlights

- Age, gender, education qualifications, relevant work experience and current research/academic position are the most common eligibility criteria of research awards across the countries studied
- Some countries, including India make awards under specific schemes only on the basis of nomination by host institution of the researcher
- Some awards and funding appear to be directed towards reversing the 'brain drain' by getting the STEM talent back into India. A more thoughtful and focussed approach in specific fields of national importance might be a better route to follow

3. Selection Criteria & Provision of Feedback

Pre-disclosed selection criteria is immensely essential for researchers as it enables them to tailor their proposals to the desired outcomes of the schemes. Out of all the countries studied, China is an exception in the sense that selection criteria are determined by individual host organisations who send proposals to a joint committee. Similarly, the countries under consideration have devised varying methods and procedures to assess the suitability of a proposed project. For example, Japan's KAKENHI scheme follows a peer review process in two stages: a document review followed by a comprehensive review. Furthermore, an audit of the review process is conducted to ensure that the established rules were followed without prejudice.

Certain common criteria determined by funding agencies across these countries, include the following:

» Importance and possibility of innovation and impact

The significance of the proposed project and its potential impact via innovation and new technology are some important determinants for these countries while reviewing a proposal. The same is true for India as well, with several schemes aiming to translate the findings of the proposed research into larger projects that promote general welfare. This criterion is a manifestation of the government's goals behind incurring R&D expenditure. Scientific progress and technological innovation are perceived as instruments capable of ensuring public good and improving present systems.

» Adequacy of Methods

While assessing applications, funding agencies also check whether researchers are intellectually and organisationally capable of carrying out the proposed research. There are two main indicators of this criterion. In India and many other countries, this is determined by looking at the researchers' previous work, qualifications and contributions made to the field. Second, funding agencies also evaluate the proposed methodology and assessment tools to gauge if these would be sufficient to carry out the entire research.

After the submitted proposals are evaluated, funding agencies of the studied countries provide information regarding the assessment to the applicants. Unlike India, researchers in these countries receive feedback for their applications. For instance, applicants to KAKENHI in Japan receive their proposals' approximate ranking, opinions and results from the review stages, along with a standard format feedback.

The degree of information from the review process disclosed varies. For instance, South Korea considers applications made in different stages (qualifications review, comprehensive review) differently. Applications that were disregarded after the qualifications review stage receive information on the reasons behind the rejection of their proposal.

Key Highlights

- The potential impact of proposed projects and researchers' past experiences in the field are some common criteria used during the application processes across countries. Such an outlook encourages researchers to envision comprehensive end goals of their projectst
- Appropriate credit and weightage for potential impact of the research via innovation and new technology should continue to be made universally important within Indian HEIs
- Most of the countries studied in this section provide comprehensive feedback to applicants that enables them to work on their projects' limitations and present improved proposals that effectively reflect the necessity and impact of their research

4. Autonomy in utilisation of funding

It is important to understand the extent of autonomy that lies with researchers on how they wish to utilise their funds. One of the autonomy issues faced by the researchers is the issue of project-based research grants made to the researcher's respective institute instead of directly being allocated to them. Though this might facilitate ease of monitoring and administration of the grant, in case of inefficient or not well planned setups, it becomes difficult for the researchers to get access to the funds that they require, in an adequate and timely fashion. One such model is the USA's National Science Foundation (NSF). As per the Grant Policy Manual of NSF, "NSF grants are normally made to the grantee organisation and not individual project investigators/project directors" (NSF 2002).

On the other hand, the discretion on 'how' the fund should be utilised has been well-defined by certain countries in such a manner that it provides autonomy while having certain pre-defined guidelines and monitoring mechanisms in place. Consider the example of KAKENHI, 'grants-in-aid for scientific research'—one of the most popular ways to receive research grants in Japan, given the wide variety of research fields it funds. It has separate fund utilisation guidelines and rules for single-year grants and multi-year grants. While a single-year grant requires that the grants must be utilised by the end of the fiscal year, the multi-year grant allows utilisation of the grant as per progress of the project, without any compulsion on spending it as per the fiscal year divisions. However, any mis-utilisation or inappropriate utilisation of the grants may result in stringent penalties and/or framing of criminal charges.

Another important example is South Korea's NRF's funding. It has elaborate and specific utilisation guidelines for every component of the grant (including salaries, research material, indirect costs, etc). This ensures minimum ambiguity and clearly lays down the utilisation criteria and requirements for each component and sub-component of the grant (Guidelines for Proper Spending of NRF Funding).

Revisiting the example of Japan yet again—discretion of utilisation of research funding has been addressed by the country for institutional grants as well. Post corporatisation of the national universities, all 86 of the national universities of Japan have the discretion to determine the internal allocation of the grant received, once MEXT calculates and provides it to them. The universities can decide how it needs to utilise it for research, teaching, social services and management-related activities. Though the universities prefer such discretionary grants, the government has been gradually decreasing the amount year-by-year and shifting its focus towards competitive and project-based funding (Maruyama 2007).

Key Highlights

Autonomy of utilisation of grants depends on 'who' the money is allocated to (institution or directly to researcher) and 'how' the money can be utilised—based on grant period, project progress, etc.

While setting adequate controls for accountability of fund usage, timely disbursement and in appropriate tranches are important for ensuring the optimal ROI of research funding

5. Duration of funding

The United Kingdom and Israel have a typical funding duration of 5 years. Germany also shows a similar trend of the duration typically ranging from 2 to 5 years. Japan also has project durations typically ranging from 3 to 5 or 6 years with a few extending to 7 years for some 'truly necessary' cases. Interim, post-project and follow-up evaluations are done for each project, the results for which are also made available to the public.

One of the rare examples in this study that provides for several long term funding options is South Korea. The duration of research funding in South Korea typically ranges from 1 to 10 Years. Several programs also provide follow-up support for a few additional years after the conclusion of the research period for projects with outstanding performance.

Earlier the research funding provided by China's central government used to be upto 5 years. However, government funding programs such as the Program 973 (National Basic Research Program) have now updated their model to 2+3 years, where research projects have to mandatorily undergo a rigorous assessment at the end of 2 years that decides the further allocation of funding to the concerned project for 3 more years. The C9 league particularly includes 9 universities selected for a funding period of 3 years. USA's NSF also typically supports projects for the duration of 3 to 5 years. However, certain programs such as the Long Term Research in Environmental Biology (LTREB) intend to support decadal projects. Funding for the initial 5-year period and the second 5 years support requires submission of separate proposals, the latter being a shorter renewal proposal with only a 10-page project description.

The lacuna of availability of long term funding and the mechanisms to locate long term funding are two of the key issues that need to be addressed across several countries. India's National Research Foundation draft section 7.13 on Public Disclosure attempts to address the issue of locating the ideal funding and states "All proposals funded, together with the amounts of annual funding and duration of funding, annual updates on progress,and final results achieved will be publicly displayed on the NRF website".

Key Highlights

- The typical duration of grants for most of the countries studied ranges from 2 to 5 years with few exceptions of schemes with 7-10 years duration
- Evaluation of the need to reconsider grant duration was seen as a good practice in countries such as South Korea and China
- Lacuna of long term funding is a key issue that needs to be addressed across several countries

Conclusion and Recommendations

The announcement of a National Research Foundation (NRF) brings in a new hope for India's R&D higher education ecosystem that has waited for decades to get its rightful due. This report is thus an attempt to shed light on some of the pressing issues that ail the country's research funding ecosystem and put forth certain recommendations with a view to improving the same.

1. Importance of Data

India must look to answer the what, who, when and how of research funding data. In other words, we need to answer the following questions: what data is needed, who will collect it, how & when will it be collected and how will it be used?

Institution-wise funding, utilisation of those funds and research funds per student population are a few of the many types of crucial data points on research funding that India needs to collect. If it successfully does so over the next few years, India will be able to compare trends in these statistics by aligning them with the development needs of its economy and higher education sector.

The problem of aggregated statistics must also be addressed with urgency. The current aggregated statistic of the overall expenditure on R&D by the higher education sector as a percentage of the total R&D expenditure of the country tells us very little about the policy changes that need to be made to ameliorate the current situation of university-based R&D. There is also a need to identify one body/entity—either a ministry or an independent body—to be tasked with collecting the R&D funding related data for HEIs. This shall also be in line with NRF's aim on public disclosure to capture information on "All proposals funded, together with the amounts of annual funding and duration of funding, annual updates on progress,and final results achieved" to be publicly displayed on the NRF website (PSA 2020).

What is measured is treasured. It is important that we understand this with respect to R&D data. An effort by the government to publish periodical granular data and statistical evidence on the R&D contribution of the higher education sector can go a long way and give much needed impetus to public interest and private investment in university-based research.

2. Publish detailed guidelines for effective utilisation of the research funding

South Korea's 'Guidelines for Proper Spending of NRF Funding' is an excellent example of detailed guidelines being provided for each grant component's utilisation. It also comprehensively maps out the documents to be submitted in case of approvals for the utilisation of grant for that particular cost (salaries, materials, research activity, etc) (Guidelines for Proper Spending of NRF Funding, 2019). Implementation of such a system in India would provide uniformity and clarity, while promoting adherence to the guidelines. It would also facilitate redressal/penalising procedures in case of misutilisation of the grant.

3. Institution-wide monitoring and reporting of research funding by the HEIs

Currently, the higher education institutions do not follow a uniform structure while reporting information on research funding received and utilised by their research projects. The monitoring and evaluation of these projects is also ambiguous with no public release of the method or results of such evaluation. We must realise the importance of monitoring and reporting of this data to appropriately place it in relation to the qualitative and quantitative research productivity outputs. Scientific publications should not be viewed as the ultimate output of government-funded research projects. Research administrative support must also be taken into account to facilitate such reporting so as to not compromise on research productivity.

4. Uniformity in indirect costs

A uniformity and clarity in charging of indirect costs shall help the researchers to take into account the funds that they will have to allocate for indirect expenses such as overhead costs. This could be either in the form of a predetermined formula or capping of the indirect costs as a percentage of the direct costs or as a percentage of the total award.

5. Transparent selection criteria

Apart from the basic details about the selection process for the awards, funding agencies should also publicly make available data on members of the selection committees and the time period within which the selection completion is expected. The contemporariness and relevance of the research field may also be given due weightage as part of the selection process.

6. Feedback mechanism

The funding agencies must provide constructive feedback to all research proposals received, in case of both selection and rejection of a proposal. This feedback should include rating elements, opinions that were expressed by selectors during the review and an approximate ranking. Japan's KAKENHI program's selection process mentioned earlier is an excellent example to learn from. Not only does it provide detailed feedback but an audit review of the selection is also conducted to ensure that a fair selection has been made. A good point for India to start adoption of such a practice would be by conducting a pilot audit review of grants with large award amounts.

7. Information on funding schemes/ programs

All essential information on funding schemes/ programs of the funding agency should be made available through lucid categorisation and relevant details being provided on a common filter-enabled portal on the basis of fields funded, duration of the grant, eligibility, grant amount, individual/ group research, etc. The NRF website can take this recommendation into consideration while listing data of research funding sources as envisioned in its draft section 7.13 on Public Disclosure (PSA 2020). The current 'India Science, Technology and Innovation' website by the government only lists schemes/ programs by 'Category' of support, one of which is 'Research & Development' (DST 2021).

8. Duration of funding and need for evaluation

Sufficient options need to be created for funding of long term projects as well as the provision to evaluate the need to extend the grant beyond the stipulated grant duration.

Mid-term/periodic evaluation at specific periods of the project should also be practiced in all mid to long term research grants. This shall help to determine the following:

i. the need for additional funds, or
ii. the need for the reduction of funds for the follow-up grant, in case found to be unnecessary/not required for the project, or
iii. in cases of non-realisation of predetermined performance criteria (if any), the concerned funding agency may also consider attaching financial consequences based on the performance, if decided and agreed at the time of project initiation.

Recommendations Recap

1. Importance of Data on University-based R&D
2. Publishing detailed guidelines for proper utilisation of the research funding
3. Institution-wide monitoring and reporting of research funding by the HEIs
4. Uniformity in indirect costs
5. Transparent selection criteria
6. Feedback Mechanism
7. Information on funding schemes/ programs
8. Duration of funding and need for evaluation

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Appendices

Appendix A: India's Funding Schemes & Agencies

Name of Agency	Name of Scheme	Duration of Grant (in years)	Nature of Scheme
Department of Science and Technology	Swarnajayanti Fellowship	5 Years	Research Grant: Rs. 25,000/month
	INSPIRE Faculty Fellowship	5 Years	• Research Grant: Rs. 7,00,000 per year • Travel: Rs. 70,000 per year • 60% of grant for recurring expenses (including Project Manpower, Travel, Consumables & Contingencies) • 35% of grant for Capital Equipment • 5% for Overhead
	Mission on Nano Science and Technology	3-5 Years	Funding to individual scientists/groups of scientists for basic research
Department of Biotechnology	Ramalingaswami Re-Entry Fellowship	5 Years (can be extended +2 Years)	• Research grant: Rs. 10,00,000 for first two years, Rs. 7,50,000 for third & fourth years and Rs. 5,00,000 for the fifth year • Monthly allowance: Rs. 1,00,000
	S Ramachandran - National Bioscience Award for Career Development	3 Years	• Research grant: Rs. 5,00,000 per year • Prize: Rs. 2,00,000
	Har Gobind Khorana - Innovative Young Biotechnologist Award	3 Years	• Research grant: Rs. 10,00,000 • Fellowship amount: Rs. 1,00,000 per year • Covers equipment, travel, manpower and contingency

Name of Agency	Name of Scheme	Duration of Grant (in years)	Nature of Scheme
Science and Engineering Research Board	Core Research Grant	3 Years	• Financial Support to individual and groups of researchers • Covers equipment, manpower, travel and overhead charges
	Ramanujan Fellowship	5 Years	• Research Grant: Rs. 7,00,000 per year • Fellowship amount: Rs. 1,35,000 per month • Overhead charges: Rs. 60,000 per year
	J C Bose Fellowship	5 Years	• Research Grant: Rs. 15,00,000 per year • Monthly Stipend: Rs. 25,000 • Overheads to host institutions: Rs. 1,00,000
Indian Council of Medical Research	Ad-Hoc Project Funding	3 Years	• Financial Ceiling: Rs. 1.5 crore (entire duration) • Covers travel, equipment and overhead costs
	Emeritus Scientist Scheme	1 Year (Renewable up to 3 Years)	Honorarium: Rs. 1,00,000 per month
	Cohort Studies	5 Years	• Financial Ceiling: Rs. 2 crore per year • Covers travel, equipment and overhead costs
Council of Scientific and Industrial Research	Shanti Swarup Bhatnagar Prize	One-time Award	• Award amount: Rs. 5,00,000 • Honorarium: Rs. 15,000 per month (up to 65 years of age)
	Emeritus Scientist Scheme	3 Years	• Monthly allowance: Rs. 20,000 • Technical assistance • Covers medical allowance, equipment, travel and contingency costs

Appendix B: Charts

Table for Chart 1

R&D Expenditure as % GDP by Continents

Continent/Year	2010-11	2015-16	2017-18
Africa	0.4	0.46	0.47
Asia	1.43	1.57	1.61
Europe	1.74	1.84	1.86
Latin America and the Caribbean	0.66	0.73	0.67
Northern America	2.66	2.63	2.69
Oceania	2.16	1.77	1.78
World	1.62	1.69	1.72

Table for Chart 2

Expenditure on R&D by Continents (billion PPP $)

Continent/Year	2010-11	2015-16	2017-18
Africa	18.06	27.3	30.03
Asia	545	850	995.45
Europe	362.8	453	503.28
Latin America and the Caribbean	53	80	67.07
Northern America	434.99	522.11	570.42
Oceania	22.29	23.3	26.12
World	1435.89	1947.77	2192.38

Table for Chart 3

Country-wise GERD (Expenditure on R&D as % GDP

Country	% of GDP
India	0.7
United Kingdom	1.7
Republic of Korea	4.6
Israel	4.5
Japan	3.2
Germany	3
USA	2.8

Table for Chart 4

GERD performed by Higher Education - funded by Government (in 1000 current PPP $)

Country Name	2017
China	19229996
Japan	10400804
Germany	19248062
South Korea	5952458
Israel	1076884
United Kingdom	7436097
India	3770054

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