R&D Funding in India: An Empirical Study[1]

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ABSTRACT *Although the national expenditure on R&D in India (as a percentage of GNP) is comparable with that of such developed countries as Australia and Canada, there is increasing concern that the S&T capabilities of the country are not being fully utilised for accomplishing developmental plans. We report some of the findings of a sponsored project which examines R&D funding by government agencies in India.*

Keywords: R&D funding, India, government research, research policy.

Background

In the nearly 50 years since India gained independence, science and technology (S&T) has played a significant role in the economic development of the country. This is reflected in the green revolution, the exploration of oil and natural gas, the establishment of the Atomic Energy Commission, and the entry into the space era. In pursuance of the Scientific Policy Resolution, which the government of India adopted in 1958, the national expenditure on R&D, as a percentage of GNP, has grown steadily from 0.17% in 1958–59 to a little over 1%, a figure that is comparable with such developed countries as Australia and Canada.[2] Nevertheless, it is a matter of ongoing concern to the Indian Ministry of Science and Technology (MST) that the scientific and technological capabilities of the country should be effectively deployed for accomplishing the nation's developmental plans.

A manifestation of this concern was the sponsorship of a pilot project by a major government funding agency (referred to here as GA1), which reviewed 28 major R&D projects for which grants greater than Rs 5 million had been given during the seventh 5 year plan. (At current exchange rates, one US dollar is equivalent to about Rs 36.) The objective of this project was to ascertain the progress made in each of the 28 projects, assess the effectiveness of the R&D efforts in each, and evaluate the extent to which the stated objectives were fulfilled in each project. The projects were variously drawn from the fields of power engineering, geo-sciences, electronics, and biological sciences.

With the help of experts selected from leading research institutions, the following criteria were used to evaluate the projects:

1) whether the project had indeed made useful contributions to basic science, or had met the needs of the country within the aims and specifications of the project;
2) whether the cost of the project had been commensurate with the results obtained;
3) whether the time scale of the project was justified and whether obsolescence had overtaken its completion; and

0810-9028/99/010021-11

4) whether general conclusions could be drawn from this study to guide the future choice of projects and their better implementation and management.

The pilot study on major research projects revealed that the prevailing environment in many places was not at all conducive to carrying out innovative and creative research activities. The non-availability of such essentials as water, chemicals, consumables and power was a major factor contributing to delays in the implementation of research projects. Simple testing instruments, repair and maintenance facilities, and dust-free rooms for sophisticated equipment were lacking not only in universities, but even in such advanced centres as the Indian Institute of Science. The pilot study also reported that the funding mechanisms of the sponsoring organisations had several deficiencies, such as bureaucratic procedures which demanded considerable time and energy from the research scientists. The study also criticised the existing system of review and evaluation of project proposals and ongoing projects.

Based on the findings of the pilot study, GA1 sponsored a major, 3-year study in which the first author participated as a research fellow. The initial objective of the study was to evolve uniform guidelines which were to be followed by different public-sector R&D funding agencies for evaluating project proposals so that their funds for R&D could be effectively utilised. (Together, these agencies account for more than 70% of the annual expenditure on R&D in India.) The scope of the project was subsequently enlarged to encompass all aspects of the administration of R&D by GA1 and allied government agencies.

The need to develop such a model policy for the administration of federally supported research has also been espoused in the context of the US.[3] Such a policy would help funding agencies and institutions to cope with lengthy and complex regulatory requirements, decentralisation and devolution of authority, and the issues of accountability, communication, and standardisation. The policy could encompass both a broad discussion of the basic philosophy of the research assistance relationship and the expectations and responsibilities of the parties to it, and specific operational standards and procedures applying to grants.

The Process of R&D Administration by Government Funding Agencies

The process by which GA1 and allied government agencies administer their funds for S&T projects can be described as follows. Every 5 years all the funding agencies within the purview of the Ministry of Science and Technology decide upon the thrust areas and research priorities for S&T in India. The panel is composed of both academics and the heads of the funding agencies. The agencies then publicise these plans in two ways. Firstly, they send out circulars to national research laboratories and academic institutions. Secondly, every year they organise a 1-day forum to disseminate information about thrust areas, the funds available and application processes. In this forum, they describe the procedures that they follow for administering their funds.

The organisational structure for S&T is as follows. The MST comprises various agencies, such as the DST (Department of Science and Technology), DBT (Department of Biotechnology), and DoE (Department of Electronics). Each agency is headed by a director, who is assisted by joint directors. Joint directors in turn supervise program officers and research fellows. The joint directors along with these supporting personnel, make up various PACs (program advisory committees).

Any project proposal which seeks funds of less than Rs 1.2 million is reviewed by only the PAC. If a proposal requests more than Rs 1.2 million, then it has to be reviewed by

the SERC (Science and Engineering Research Council) as well. The review of such proposals is accomplished by peer groups, which are constituted by the SERC purely on a temporary basis, and solely for the purpose of reviewing major projects. Typically, such groups are formed on an *ad hoc* basis to review fresh proposals and meet only twice a year.

Once a proposal is accepted, there is usually a 6-month lead time before funds are actually sanctioned. Often, the research investigators are under tremendous pressure to spend large amounts of money in a relatively short time (often just 3 days) before the close of the financial year. Unless they spend the budgeted amount, the funds for the next year will not be released. Every 6 months, project reports must be submitted for projects which last 2 years or longer. For projects of shorter duration, quarterly reports are due. Most of the projects (about 70%) request either further funds and an extension, or funds for a spin-off project. Once the projects are complete, the project reports are indexed and sold to interested industrial clients. The view has been expressed that the process of dissemination should be initiated at the stage of idea generation itself, not after the completion of projects.

Methodology for the Present Study

The Pilot Study

The pilot study entailed a field trip by the first author to GA1, where she informally interviewed the director, eight joint directors, and 12 members of PACs. The objective of the pilot study was to gain a thorough understanding of the funding policies and procedures followed by GA1 and allied agencies. Therefore, the interviewees were those personnel at various levels in the organisational hierarchy within GA1 who were directly involved at different stages in the funding process.

Since the project was sponsored by GA1, most of the interviewees in the pilot study belonged to it. Nevertheless, so that other governmental R&D funding agencies could benefit from the research project as well, the first author also visited five other funding agencies and interviewed their directors. These agencies were the DBT, the DoE, the DRDO (Defence Research and Development Organization), the DoS (Department of Space), and the DOD (Department of Ocean Development). The interviews lasted for a total of about 50 hours.

The questions for the interviews in the pilot study focused on the nature of the funding process, the various problems, and methods for their resolution. They are formally listed below.

1) How do the agencies decide on their thrust areas and how do they ensure that all relevant disciplines are appropriately funded?
2) What are the measures taken by the funding agencies in advertising details of the thrust areas and available funds to the research institutions?
3) How can the funding agencies improve the existing documents and brochures, such as the form for submitting proposals?

The interviews also dwelt on the historical evolution of the administration of funds by GA1 and allied agencies.

The Follow-up Study

The dominant issues which emerged from the interviews which the first author conducted in the pilot study included proposal submission, peer review, interim reports, budgets, inter-agency interaction, evaluation of the completed project, follow-up, second-line

institutions, and thrust areas. Consequently, the questionnaire focused on each of these in turn, and thereby spanned all aspects of the funding and project cycle. We either mailed or distributed in person 50 questionnaires all over the country, to scientists and academic researchers. In this manner, we sought to understand the perceptions of applicants for funds, those who were at the receiving end of the funding process.

Of the 50 questionnaires, 34 were returned, duly completed. The entire process, from questionnaire design through to data collection and analysis, took a total of about 5 months. We also interviewed eight selected respondents who were investigators in frontline and second-line institutions. These included: (a) investigators who always secured funding for their project proposals (often they were on the SERC); (b) investigators who were either only partially successful or had to revise and resubmit their proposals to various agencies before finally getting their projects accepted; and (c) investigators who were never successful. We also made field trips to the following organisations:

1) two frontline academic institutions;
2) an industrial client of one of these two frontline institutions;
3) three second-line academic institutions;
4) one research institute; and
5) a central facility which houses equipment for research purposes, and which provides consultancy services for academic institutions and industries. (For example, many students of one of the three second-line institutions visit this facility for their laboratory work, and the nominal fees for usage go towards maintaining the equipment.)

The ensuing discussion comprises a summary of the responses to each topic in the questionnaire. All quotations represent respondents' remarks in verbatim.

Thematic Analysis of Field Data

Submission of Proposals

The required format for submitting project proposals is long-winded, requiring irrelevant details, such as the investigator's marital status. Depending on the funding agency, 15–25 copies of the proposal are required. In a small institution, the overheads for submitting proposals (printing, photocopying, binding, and postage) can be substantial. Respondents have suggested that the submission process be streamlined by requiring that the investigators send a diskette containing the proposal. If the funding agency wished to pursue the matter further, the investigators would furnish several hard copies of the proposal.

The Peer Review System

Many respondents felt that peers should be selected on their research contributions, and not on their visibility, high profiles, or affiliation to elite institutions, as is presently the case. According to them, peer reviews are highly opinionated. While peer reviews are important and even necessary, they should essentially be constructive and supportive. Some peers do not want outsiders (members who do not belong to their cliques) to benefit from the agencies. Hence, they become destructively critical and do not give researchers an opportunity to revise their proposals. The cliques get funded all the time.

One investigator said that one could clearly trace the academic lineage, to the peer reviewers of those researchers whose project proposals had been accepted.

Similar views have been expressed of the peer review system in the US; it has been criticised as having an intrinsic, anti-innovation bias and as being founded on the mistaken premise that reviewers will act in an unbiased manner in situations involving a conflict of interest.[4] The lack of a rigorous peer review system has also been described in the context of Korean R&D.[5] In Poland, research grant applicants have questioned the competence of the assessors of project proposals, as well as the fairness, impartiality and reliability of the peer review system which is adopted by the Committee of Scientific Research.[6]

One way to overcome biased refereeing is to introduce a two-tier system, wherein one reviewer is selected from the list provided by the project investigator, and another from the agency's list. At present, only the agency's list is considered. The peer groups are largely invariant. Often, the group does not meet on time because a leading researcher who perpetually belongs to the group is abroad and unavailable. Funding agencies are very reluctant to include youngsters in the peer groups, and prefer to continue with the established members of the group. Youngsters are never trained to become peers, and nepotism and favouritism are rampant (an 'old boys' club', as one investigator put it). Some young PAC members said that fresh blood must be infused into the peer groups because some of the older members are intransigent and out of touch with current research trends. Two senior professors in an elite academic institution, who had been peer reviewers for GA1 for several years, found that, even when they suggested the names of young and promising scientists who had the requisite time and expertise, GA1 persisted in retaining the professors. Interestingly, these young scientists were usually the post-doctoral fellows of the peers, and often reviewed the proposals because the peers did not have the time.

Interim Reports and Mid-term Reviews

Interim reports are intended to facilitate mid-term correction and stock-taking of the progress of projects. However, periodic meetings and field trips by the funding agencies may be more useful. In principle, field trips are mandatory on the part of the funding agencies to ensure that performance is satisfactory. In practice, the field trips are not being conducted by GA1 because the same peers continue to be on the review boards, and they are seldom available. In contrast, another allied government agency (which we shall refer to as GA2) has its own staff who belong to the PACs and who conduct the field trips themselves. For this reason, the administration by GA2 of its projects is considered to be very superior to that of the other agencies. In fact, GA2 has a history of terminating projects midway on account of a lack of progress. While GA1 argues that funds are unavailable for such field trips, GA2 argues that by expending funds it can prevent further (and substantial) waste of resources by not letting the project continue to an unsuccessful conclusion. Progress reports are not valued very much by GA1 because it is not clear who will read/evaluate them.

Bureaucratic Control Mechanisms

The time-lag between the submission of a proposal and the meeting of the appropriate committee is considerable. Project approvals can take about 2 years. It takes another 6 months to get the first installment. Often, 3 months or more elapse between committee

meetings and the announcement to project investigators of the status of their proposals. The bureaucratic style of funding agencies has been commented on with reference to other countries, such as the US and Poland.[7] However, bureaucratic mechanisms (such as paperwork) are missing in the government's promotion of R&D in Japan.[8] In Japan, several government agencies, including the Ministry of Education and MITI (the Ministry of International Trade and Industry), have developed systems which support cooperation between academia and the private and public sectors. Support takes the form of direct grants and low-interest loans for R&D projects and foreign technology acquisitions, selective exemptions from antitrust laws, and special tax advantages.

Japanese academic institutions have historically enjoyed unwritten relationships which allow a high degree of interaction with the public and private sectors without written contracts and agreements. A senior Japanese scientist has been quoted as saying that 'in the US, faculty spend too much time looking for money. At the University of Osaka, those projects showing particular progress or promise are prioritised to receive continued funding.'[9] In return for spending less time soliciting outside support, faculty researchers are expected to provide free consulting to companies, often at a rate of 2–3 days per week.

Evaluating Requests for Extension

As mentioned earlier, towards the close of their projects, most project investigators (about 70%) ask for either further funds and an extension, or funds for a spin-off project. Such requests can be granted only on the basis of satisfactory performance, but this is hard to judge across disciplines. One criterion that has been suggested is that a minimum number of publications should result from the research. However, because of the long lead times for publication in many areas, this criterion is not perfect. Besides, it is easier to publish a large number of papers in some research areas than in others. One senior researcher remarked that some papers are so specialised that finding peers within the country to referee them is very difficult.

Evaluation of Completed Projects

Opinions varied regarding the criteria for assessing completed projects. For example, for basic research, publications in refereed journals seemed to be the accepted criteria. Some researchers felt that the criteria ought to include such factors as the number of research students trained to appropriate levels, extent of industrial collaboration and comments from users on the utilisation of results in the case of applied research. On the whole, researchers said that the evaluation of the completed project report should be as strict as the evaluation of the project proposals. Even if this reduces the number of proposals, it is better to have a few good quality proposals than to have many poor ones. In the case of theoretical research, assessment could be in terms of the additional knowledge base at the end of the project. Other criteria specified were: cost effectiveness of the technology developed, its potential for application, spillover of the results to other areas, potential for improving any production/engineering process, reduction in manufacturing time, improved quality, and the ease of adaptation for mass production of the methods and technologies developed.

Laboratory–Industry Collaboration

Often, the needs of industry and research as accomplished by academic institutions do

not match. This is because academic institutions are often under pressure to conduct research that is on a par with that conducted in institutions in the developed West. While such Western-oriented research might enforce the careers and publications profile of individual researchers/project investigators, it is often irrelevant to the needs of indigenous industry. Hence, there is a tremendous need for institutions that bridge the gap between the expectations of industry and academic research.

In the US, the Industry–University Cooperative Research Centres (IUCRC) program, which the NSF started in 1973 as part of its Experimental R&D Incentives Program, has emerged as one of the most successful and highly leveraged government research programs to develop and transfer industrially relevant technologies from the university into practice.[10] (The NSF's modest annual budget of $4.2 million is leveraged by a factor of about 15 to 1.) Organisations pay an annual fee to support, guide and benefit from a centre's research. Membership is attractive to sponsors because it provides a way to leverage a very modest R&D investment while allowing the sponsors to work with students and faculty, and to network with other industrial representatives. In 1993 alone, IUCRC research resulted in R&D investments of about $US 100 million from sponsor organisations based on centre technologies. According to NSF officials, this 'new money' investment by IUCRC members may be the most tangible evidence that successful technology transfer is occurring. The need to support academic research that is relevant to the needs of industry has also been identified in the UK.[11] In May 1995, the government made collaboration with industry, and the improvement of UK business competitiveness, criteria for future funding of scientific research.

One problem that may be inherent in collaboration between academics and industry is the latter's desire for confidentiality. In the UK, in the area of biotechnology, industry seems to interact with universities only when there is a specific need; most research by industry is done in-house because it is the best way to maintain confidentiality.[12] From face-to-face interviews with about 50 academics, the same study concluded that those academics who had developed good links with industry recognised the advantage of building open lines of communication so that industry had the opportunity to exploit what academics discovered and so that academics had the chance to learn from firm-based research.

In the case of Japan, some analysts have argued that research links between universities and industry must be weak because regulations restrict links.[13] However, an examination of the structure and funding of universities, the indicators of the performance of Japanese science, and the regulations governing industry–university interaction, does not support the view that the universities do not produce research which is useful to industry. R&D managers in Japanese industry are reported to enjoy long-lasting relationships with academics, which continue with mutual benefits and obligations on both sides and valuable access to the wider network of the scientific community. Tsukuba University has established a new organisation called TARA (Tsukuba Advanced Research Alliance) to encourage collaborative R&D between private research institutes, the university, and government national laboratories.[14] Many companies, drawn from the electronics, pharmaceutical, and chemical industries, are joining TARA in contract and joint research.

Inter-agency Interaction

Thrust areas of the various agencies overlap to a great extent; however, the agencies do not interact among themselves. This creates several problems. The authors are aware of project proposals which were rejected by GA2 and, unrevised, were subsequently

accepted by GA1. There is a growing perception among researchers that GA1 is a last resort, i.e. if no other agency funds their research, GA1 will. This reflects the lenient standards of GA1. Often, researchers who desire large levels of support submit multiple but almost identical proposals to different agencies, and thus obtain sufficient funds for their research. There is an increasing pressure on GA1 and allied agencies to spread their funds thinly, and thus increase their coverage. Hence, they are often willing to support only a portion of the requirements of projects. One common ploy of those submitting project proposals is to overstate their requirements.

Duplication of facilities within the same institution sometimes occurs as a result of projects being accepted from different research groups within that institution, possibly even from the same agency. This problem arises because PACs even within the same agency do not interact with each other. The heads of all the agencies interviewed by the first author recommended the establishment of an umbrella agency which would coordinate the activities of GA1 and allied agencies. The head of one of the agencies said that an interim solution would be to maintain an electronic network system through which any agency could access the list of proposals under review (along with the synopses and related details).

The need for inter-agency interaction has also been identified in the Polish context. One of the reasons most frequently voiced for the discontent of grant applicants in Poland with the new research funding system is the lack of coordination and dispersion of research efforts across the various sections of the CSR.[15] In the US, cross-agency, thematic programs are becoming an increasing part of the federal research effort and are expected to take an increasing share of federal funds.[16] The Japanese government reportedly excels in the coordination of research sectors.[17] At the 16 government AIST (Agency of Industrial Science and Technology) research institutes in Japan, developed patents owned by the government are open not only to Japanese industries but also to the entire industrial world.

Second-line Institutions

In terms of support for second-line institutions, it is not project funds alone but also infrastructural development that is required (in terms of library and computing facilities). Even in frontline institutions, basic necessities, such as water and electricity, are inadequate. When a frontline institution is talking about a third spectrometer, a second-line institution is merely asking for a computer. The yawning gap between frontline and second-line institutions implies that it is not wise to think of uniform guidelines for both classes of project proposals, because second-line institutions are at a considerable disadvantage. There are both arguments and counter-arguments for earmarking pools of funds for second-line institutions. One striking counter-argument is that such earmarking is tantamount to a reservation system, not unlike that which is prevalent in the context of college admissions on a caste basis in India. In the US, a criticism of earmarking is that it may result in a lower quality scientific product.[18]

Researchers in second-line institutions do have access to facilities in frontline institutions, but often are treated in a rather contemptuous manner by their counterparts in frontline institutions. The head (and professor) of a department at a second-line academic institution recounted an instance when he sought to use the spectrometer at a lab in a frontline institution. The doctoral students in the lab talked disparagingly about the lack of facilities at his institution, and remarked that he could use the spectrometer during the lunch-break. The same professor was denied access to the photocopying machine at the lab for copying just one page, and was asked to walk a kilometre to the campus photocopying centre!

Often, funds are requested only when the project is halfway through, because projects will not be sanctioned unless there is a certain clarity and structure in the project proposal, and this clarity usually demands that much of the proposed research be executed even before the proposal is submitted. A common ploy of many researchers is to engage in several projects concurrently, and use the spin-offs from one project to form the basis of a fresh project proposal. This luxury is available only to the frontline institutions.

When funds are sanctioned for a project, they are released to the home institution of the project investigators. The funds are thereby controlled by senior authorities within the institution (such as the chairperson of the department). In one second-line institution, which is affiliated to a neighbouring university, the funds are released to the vice-chancellor of that university, and are routed to the project investigator through the principal of the institution, and then the chairperson of the department. Thus, there are delays in the administration of funds even after they have been released by the concerned funding agency.

For hiring project assistants, the funding agency's permission is required, and up to 6 months can elapse before permission is received. In frontline institutions, multiple projects are executed concurrently and the adjustment of funds across projects to support project assistants is possible. However, this is not possible in second-line institutions, which have fewer concurrent projects. In many second-line institutions, owing to the long information channels, the advertisements by GAI of the 1-day forum never reach the investigators in time. Funds for attending the forum are difficult to obtain, and the lead-time for obtaining them is very large because of bureaucratic procedures. One suggestion by respondents is that the agencies conduct the 1-day forum in major cities.

Thrust Areas

Many researchers do not know how the thrust areas are decided and often complain that some crucial areas are under-represented. They are also unclear about the guidelines followed by funding agencies for sanctioning funds. Interestingly, strikingly similar complaints have been voiced by grant applicants in Poland.[19] The thrust areas of the various agencies overlap considerably. This problem can be avoided if they are established jointly by the agencies.

Recommendations

It is important to note that the above discussion on the existing system of administration of R&D and the suggestions for improving it, is grounded in data gleaned from questionnaires, interviews and field trips conducted by the author. Based on the insight gained in the course of the investigation, we now conclude with a few recommendations for enhancing the effectiveness of the system of administration of funds for R&D of public sector agencies in India.

There is a general perception that funds are being spread too thinly across agencies to fund a number of projects. Many agencies seem to be liberal in sanctioning low-budget projects and are unusually tough on larger projects. On the one hand, this results in very slow growth of activity in less-developed institutions that are already struggling. On the other, such fragmented funding does not produce any tangible results by way of R&D. It is recommended that realistic budgets should not be trimmed. To avoid duplication of research effort, project investigators should be asked to identify, at the proposal stage, those groups of researchers who may also be working in similar areas.

Too much authority is currently given to the heads of institutions and too little to the project investigators (PIs), especially in second-line institutions. This often results in delays in the release of funds even within an institution. PIs should have more freedom than they have now in terms of spending project funds rather than having to go through exhaustive procedures and institutional hierarchies. For instance, in an attempt to loosen bureaucratic strings, the AIST in Japan has told its 15 research institutes that they can spend a special category of funds as they wish without going through a strict screening of grant applications by the AIST.[20] The amount involved is about 10% of the institutes' research funds. However, the director-general of AIST hopes to increase this to 20% in the near future. The AIST has given its institutes greater freedom and autonomy in the hope that this will encourage more flexible and competitive basic research.

The present over-insistence on co-investigators is counterproductive. Instead, individual PIs could be made accountable for the satisfactory completion of projects undertaken by them. The forms for submitting project proposals are very long. Perhaps the exercise should start with an exploratory synopsis/proposal from the PI including only essential features, such as the relevance of the work in the present as well as the near future, scheme of execution, aims and goals to be achieved, and budget details. Since so many copies of the proposal are required, agencies should ask for the complete proposals only after the synopsis is accepted. This is both time- and labour-saving as well as cost-effective. It is generally felt that the disbursement of funds should be decentralised. Agencies should have regional offices/representatives to enable researchers to have better access. Some researchers complained that their geographic distance from the funding agencies is itself a problem in procuring funds.

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