Research and development expenditure—data collection and relevant issues

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The article deals with the historical development in the data collection of R&D expenditure and manpower and its latest status. It also deals with various data sources available in the country and suggests appropriate changes in their content and presentation to make available the much needed vital S&T statistics crucial for R&D planning and funding.

SCIENCE and Technology (S&T) activities in India are undertaken by research institutions/laboratories/inhouse R&D units/academic S&T departments, which can be broadly grouped under the following sectors: central (federal) government, state (provincial) governments, higher-education sector, public sector industry, private sector industry, non-profit institutions/associations.

The extent of S&T efforts in different sectors varies in terms of quantum of resources deployed for S&T activities and the types of activities undertaken.

Over the past two decades, there is a growing need for an information system and data base on science and technology statistics (popularly called 'science statistics'). Policy makers, particularly those concerned about planning, implementation and management of science, felt the need for comprehensive information not only on the input resources, which comprise mainly human, financial and infrastructure resources, to S&T activities but also the output of such activities measured in terms of increased productivity, increased economic growth, new products/processes developed, their large-scale diffusion and impact on society. Such information could be useful for undertaking cost–benefit analyses and other economic studies as well as for efficient programming, planning and budgeting. It also helps in comparing the national efforts with other countries. With the growing awareness of these needs, a number of countries have started data collection in the field of S&T. Such a need was also felt in India for establishing a data base for resources input to and output of S&T activities since independence, but assumed seriousness since the beginning of the seventies.

India has a well-established statistical system for the economic sector. Data are being collected through various statistical systems, the major one being the Central Statistical Organisation (CSO). The socioeconomic statistical systems include the statistical bureaus/directorates under the various state governments. But these statistical systems do not collect data related to S&T except educational statistics collected by the University Grants Commission (UGC) and the Department of Education. Therefore, a need was felt for collection of S&T statistics in the country.

It may perhaps be useful at this point to trace the history of S&T data collection mechanism and changes undergone by it over a period of time. The first attempt to collect information on expenditure incurred on scientific research in India was made in 1958 (incidentally, the Scientific Policy Resolution was adopted in 1958) at the initiative of the then honorary statistical adviser to the Government of India. Data for the years 1955–56 and 1956–57 were compiled from the demand for grants of the central ministries, the state governments, UGC records, etc. The data collected had a number of drawbacks and could not be considered reliable. The budget gave only a lumpsum figure and not the break-up of expenditure on research and non-research etc, which was essential. Double counting of grants extended by centre to state governments could also not be ruled out. It was not unlikely that some expenditure on scientific research might have been grouped under other heads as well.

In 1959, an attempt was made to collect data by mailing a specially designed questionnaire to scientific institutions, universities, etc. The questionnaire sought information separately for research and development expenditure, scientific and technical manpower, etc. A similar exercise was made in 1961. The responses to these surveys were not very encouraging and the data collected were used only for preparing internal reports. In the following years, between 1962 and 1968, several meetings were held under various fora to devise methods to tackle the problem of data collection on S&T, but with limited success.

In August 1968, the Government of India constituted the Committee on Science & Technology (COST). One of the charters of the committee was to survey the existing state of science and technology in the country and

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to plan for future developments in various fields of S&T in the next 10–12 years. As a part of this exercise, the committee collected statistics on resources devoted to R&D in the country in both government institutions and the private sector. The magnitude of private-sector R&D activities and that of the state governments could not be assessed properly. Nevertheless, one could get more or less reliable estimate of the R&D effort of the institutions under major scientific agencies of the central government as they almost accounted for three-fourths of the total national R&D effort. The data collected by the committee formed an annexure to the report titled 'Annual Report on Science and Technology 1969'. It then started collecting data on R&D at periodic intervals, which resulted in two similar reports for 1969–70 and 1970–71. The coverage was gradually increased, and the report for 1970–71 has even covered data on R&D of 100 private companies in addition to government institutions.

After some success in the collection of data on R&D, it was decided in 1972 to collect more details about research efforts made in the country. A detailed questionnaire seeking information regarding expenditure on salaries and wages, consumable materials, pilot plants, original book value of capital equipment and its replacement value was finalized in consultation with various experts in the field. The response was very lukewarm and most of the respondents stated that it was not possible to provide such detailed information as no records were kept by them to facilitate this sort of computation.

In 1971, the Department of Science and Technology (DST) was set up and the responsibility of undertaking these studies was entrusted to it. Since then, it is the nodal agency in India to establish S&T statistical system and collect science statistics at regular intervals on a national scale. A separate science and technology statistics division recently redesignated as National Science and Technology Management Information System (NSTMIS) division with added responsibilities has been entrusted to carry out studies/surveys relating to resources devoted to S&T activities.

NSTMIS undertakes biennial national surveys on a regular basis to collect data for the latest three years including the year of the survey. The questionnaire for collection of statistical data is continuously examined and redesigned besides making it amenable to computerization in the light of the experience gained from previous surveys. The coverage of the private sector has increased enormously and enhanced coverage was given to institutions under the state governments. These data are processed, compiled and tabulated, and analytical reports are published. Considering the amount of work involved in processing the data, a computerized system, design and software package has been developed for loading, editing, storage, retrieval and processing of data.

For the first time, a comprehensive report with statistical data on R&D in the country titled 'Research and Development Statistics, 1973–74' was brought out. This exercise is being repeated at regular intervals and similar reports have been published for 1974–75, 1976–77, 1978–79, 1980–81, 1982–83, 1984–85, 1986–87 and 1988–89 based on the respective surveys. Over the years, in all these publications not only has the coverage been gradually enlarged but steps have also been taken to implement the recommendations of UNESCO regarding international standardization of statistics. Besides the regular reports, analytical papers based on the data collected and a number of information directories/booklets are brought out from time to time.

It may be mentioned that there is a long time lag (about one year) in receiving the filled-in questionnaires from the responding R&D institutions/units despite the

National expenditure on research and development by sector for some selected years

(Crores of rupees)

Year	Central government	State Government	Public-sector industry	Private-sector industry	Total
1976–77	268.78	25.20	31.76	48.42	374.16
1978–79	357.30	40.24	55.19	75.87	528.60
1980–81	494.12	59.34	86.37	120.69	760.52
1982–83	789.54	97.05	122.46	196.98	1206.03
1984–85	1251.03	126.11	171.22	233.19	1781.55
1985–86	1455.44	162.78	198 62	251.94	2068.78
1986–87	1803.98	164.56	235.70	291 63	2495.87
1987–88	2154 .28	183.92	288.47	310.27	2936.94
1988–89	2513.79	232.91	361.32	363.79	3471.81

Source: Department of Science and Technology.

Note: 1. A number of organizations are engaged in scientific and technological activities, such as weather forecasting, geophysical surveys, teaching, consultancy, etc. In addition, they also undertake research for which in a number of cases no separate account is maintained. Wherever such details have not been provided, their expenditure on research has been estimated.
2. The number of units in the private sector varies from year to year.
3. 1 crore = 10 millions.
4. Central government excluding public-sector industry.

concerted effort and follow-up by NSTMIS, besides the problem of a number of filled-in questionnaires being incomplete or with inconsistent data. As a consequence of these, the publishing of the final report gets delayed. However, DST continues to try hard to minimize the delay in bringing out the research and development statistics reports, as they enjoy wide circulation and act as source books for S&T policy makers, planners and researchers. Care is being taken to estimate nonresponse, and for this, demands for grants/annual reports of the central ministries/departments, expenditure budget documents of ministry of finance, files on inhouse R&D units of the industries available with Department of Scientific and Industrial Research (DSIR), past questionnaires and all other available reports are used.

It is in order to discuss now the R&D budget/expenditure data found/not found in the documents mentioned in the preceding paragraphs and how these documents in the present form do not help completely to estimate nonresponse, though there is no doubt that these documents could serve as a rich source of information on R&D with required change in the style of presentation.

The demands for grants reports or expenditure budget documents published by ministry of finance for the socioeconomic ministries/departments do not give R&D budget/expenditure separately though this is by and large given for scientific departments. Very often, these documents give three types of data on R&D expenditure—budget estimate, revised estimate and actual expenditure. It may be mentioned that actual expenditure is normally available with two years gap. Invariably, budget estimate and actual expenditure for any year for any department vary significantly with budget estimate always being higher, and so using budget estimates for R&D expenditure in case of nonrespondents might inflate the total national R&D expenditure. Since there is no other better source which can be tapped for estimating R&D expenditure of nonresponding R&D institutions of the central ministries/departments, demands for grants/expenditure budget reports serve as the important data sources. Break up of R&D expenditure into revenue and capital expenditure will not be possible even from demands for grants as they are not given separately for research institutions/projects/schemes. The demands for grants/expenditure budget reports do not provide any data on personnel employed for R&D activities. Hence, the estimation of R&D manpower for nonrespondents is not possible from these documents. The annual reports of ministries/departments, yet another vital source of information, do not follow uniform format to provide R&D expenditure and its further break-up. To start with, if a beginning could be made in the annual reports of scientific departments/agencies to provide data on R&D expenditure, its break-up into revenue/capital, types of research and R&D manpower, it will go a long way to improve the reliability and consistency of R&D resources input data since these agencies constitute the major R&D performer accounting for a share of around 65% of the total national R&D expenditure. Having mentioned the limitations of the above government documents, it is perhaps useful to explain the desired changes in the presentation of budget/expenditure data on R&D.

DST has been designated as the nodal agency to coordinate Science and Technology Advisory Committees (STACs) set up by various socioeconomic ministries. The STAC mechanism exists in 19 ministries/departments, with more departments in the process of setting up STAC. In order to address interdisciplinary problems cutting across the various socioeconomic sectors, an Inter-Sectoral S&T Advisory Committee (IS-STAC) has also been set up in DST. The STAC and IS-STAC mechanisms can be used to impress upon the ministries to streamline the presentation of data on R&D expenditure and manpower in their forthcoming demands for grants and annual reports as well as in their internal statements. The ministries/departments can try to provide break-up of total R&D budget/expenditure by plan and non-plan and by capital and recurring expenditure. The above is possible only if there is some systemization of financial data of the ministries. Since PCs are available now, the above should not be a problem. In order to avoid double counting of R&D expenditure, the ministries/departments/agencies should give their contribution by way of sponsored/extramural projects to academic and other institutions which are not their own so that these could be properly accounted for while compiling national R&D expenditure by source and performer. For other sectors—state governments and industrial sectors—R&D expenditure by source and by performer are more or less the same since the contribution of these sectors to academic institutions for R&D activities is not significant. No precise data are available on the quantum of foreign funding for R&D activities.

The Planning Commission, being another source of information, invariably provides only plan expenditure on R&D for most of the ministries/departments in a reasonable time but non-plan expenditure data suffer from large delay. It will be useful if the Planning Commission keeps track of plan and non-plan R&D budget expenditure of all ministries/departments since such data/analyses are most relevant for planning purposes. By doing so, nearly 80% of the R&D data requirement will be met or at least these documents could be used for estimating nonresponse.

Having discussed about gaps in the R&D expenditure/budget data of the central government ministries/agencies (generally called central sector), it is perhaps useful to discuss the status of R&D expenditure data availability from state governments. The state government

R&D institutions are broadly of two types—those under agricultural universities and others under state government departments. Agricultural universities receive R&D funds from both the respective state government and the Indian Council of Agricultural Research (ICAR) besides some foreign funds including some from international agencies.

Usually all the research institutes/stations under agricultural universities and state government departments are approached to get data on R&D expenditure besides approaching the vice-chancellors of agricultural universities and state chief secretaries. It is understood that ICAR does not keep track of information on R&D expenditure/budget of the agricultural universities though it funds in good measure both agricultural education and research in agricultural universities. At present, there is no source from which one could collect data on R&D expenditure of state government research institutions except from the institutions themselves. ICAR could create a separate data base to compile data on R&D expenditure of agricultural universities and research stations under them, since ICAR has interactions with all agricultural universities. Every agricultural university has a director in charge of research, and information on R&D should be available in the directorate. Care should be taken to keep R&D data in uniform manner by all agricultural universities and for this necessary instructions both by the state governments and ICAR are required. Once this is done, there should not be any problem for getting the data on R&D expenditure and its break-up under different heads/subheads. By this way, double counting of ICAR R&D funding could be avoided. Care should also be taken that expenditure on extension and demonstration activities related to R&D activities should only be counted for adding to R&D expenditure. The annual reports of agricultural universities, yet another rich source of information, should provide separately data on R&D expenditure and manpower.

For collection of data on state government R&D institutions other than those under agricultural universities, the state S&T councils and the Planning Commission in the central government can play a major role, as the Planning Commission has annual and Five-Year Plan discussions with state governments. Most of the state governments have set up departments of science and technology, which should also coordinate with state S&T councils and the Planning Commission to keep and update data on R&D. In terms of quantum of R&D expenditure, the share of the state sector constitutes less than 10% of the national total. Out of the total state-sector R&D expenditure, agricultural universities account for more than 90% and therefore R&D data from agricultural universities are very crucial for getting a correct picture of state R&D funding. As mentioned above, it should not be difficult to streamline the R&D data capture and retrieval by the involvement of ICAR, agricultural university research directorates, state S&T councils, state departments of S&T and the Planning Commission in such an exercise.

Regarding the R&D expenditure data of the industrial sector, the problem of data collection/estimation could be overcome by making the companies having inhouse R&D units publish R&D data separately in their annual reports/balance sheets. It may be worth noting that the ministry of industry (department of company affairs) has published (see *Gazette of India* dated 31 December, 1988) that from 1, April 1989 it was mandatory that every company publish particulars on capital, recurring and total expenditure on R&D and its percentage in total turnover in the report of its board of directors. If such information is given by the companies, reliable R&D expenditure data for the industrial sector would be available. The directive of the government is not strictly followed and so R&D data are not readily available from the company reports. In the absence of the above, DST takes care in estimating the nonresponse by resorting to the files available with DSIR, which is the nodal agency for registration of inhouse R&D units. There are certain problems in using the files maintained by DSIR as the annual returns from registered inhouse R&D units are not the latest and so the data for the latest year are not possible. It needs close monitoring by DSIR to insist that inhouse R&D units send up-to-date annual returns regularly. Since DSIR receives several copies of annual returns, one copy could be sent to NSTMIS, where data on R&D are required. Alternatively, DSIR can regularly bring out reports containing industrial R&D data covering all inhouse R&D units which can be readily used by NSTMIS. Without the industrial R&D data, the national perspective of R&D resources input is not possible. For public-sector inhouse R&D units, besides the board of directors/ annual reports, demands for grants of the respective administrative ministries/departments could give public-sector companywise R&D data. The Bureau of Public Enterprises (BPE) can play a major role in the R&D data compilation as BPE prepares extensive documentation of public sector enterprises. Besides the above, there are specialized industry associations which can play a role in making available industrial R&D data.

Having mentioned the methodology of R&D data collection, associated problems and mechanism to improve or at least minimize the gaps, it may be pointed out that there is conceptual difficulty in defining the terminologies associated with research and experimental development popularly called 'R&D'. There exists no national definition of the term R&D.

There is a mix-up between R&D (comprising basic research, applied research and experimental development) and other related S&T activities. R&D and other related S&T activities together constitute S&T activities.

Very often, there is difficulty in distinguishing between the various types of R&D activities and apportioning resources between them. This happens mostly in the headquarters of scientific agencies/departments where more of S&T-related activities are being done rather than R&D activities. The Indian reports adopt the definitions given in the UNESCO manual, which itself is a modified version of the OECD manual (popularly known as the 'Frascati' manual).

The national survey of R&D activities of DST does not cover the academic sector as the data collection faces dual problems — conceptual and operational. The academic sector is neither cohesive nor responsive. This is so since the faculty are involved in both research and teaching and are scattered in various S&T departments of the universities/postgraduate colleges. So, it is not easy to make them respond to the questionnaire, nor are the vice-chancellors or registrar's offices found to be of any help or effective. It is difficult to apportion expenditure between teaching and research except for sponsored (extramural) projects. Even for sponsored projects, data collection is extremely difficult from this sector, as the response rate is very poor.

Having outlined the mechanism of data collection and the problems encountered, it is useful to give a brief analysis on the share of R&D expenditure between different sectors over the last 15 years for which detailed data are available. The central government, excluding public-sector industry, accounts for nearly 70% of the national R&D expenditure, while state governments account for around 10%, and industry, comprising public and private sector, accounts for the remaining 20% of national R&D expenditure. This *inter se* share between sectors has not changed over the last several years. This is one of the important inferences drawn from the time series data on R&D expenditure. Likewise many more inferences/signals are possible using the trend of R&D expenditure within sectors/subsectors and between sectors. So R&D expenditure data and analyses can play a major role in understanding their trend so far and in deciding the desirable change in trend and priorities for the future. For such in-depth analyses, data on R&D budget/expenditure are extremely important and they should be reliable and made available in time.

Cost reduction through value engineering

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Value engineering and value analysis are organized efforts with the aim of overall cost reduction without affecting the quality and performance of product/service; thus ensuring 'value for money'. Application of commonsense, logical and lateral thinking, willingness to experiment and innovate and reasonable knowledge of the subject matter are the basic requirements of value engineering. Best results are obtained when it is a team work with a multi-disciplinary group drawn from various departments such as, design production engineering, laboratory, manufacturing, quality, commerce and finance.

VALUE is the sum of those properties embodied in a product or service that enable it to accomplish its intended functions without sacrifice in any of the parameters of performance, cost and prompt delivery. A product or service is generally considered to have a good value if that product or service has appropriate performance and cost. Or, by reverse definition, a product is considered not to have good value if it lacks either appropriate performance or cost. Value can be increased by either increasing the performance or decreasing the cost. More precisely:

– Value is always increased by decreasing cost (while, of course, maintaining performance)

– Value increased by increasing performance if the customer needs, wants and is willing to pay for more performance

The value of a product depends on factors partly determined by its controllable characteristics such as the quantity and types of raw materials needed, the methods and procedures of manufacture, the performance specifications on which the design is based, and the like, and partly by circumstances and conditions outside the control of the designer such as changing market conditions and the vagaries of consumer demand. Anything that affects costs will of course affect value.

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