# Post-independence science policy and science funding in India

*Dipankar Mukhopadhyay*

*The present article traces the course of science policy formulation and science funding in India. While in the pre-independence period the private trusts and endowments played a pioneering role in encouraging higher studies and research in science, it is the Government which has been the major fund provider since independence. The article further highlights the thrust areas in various science and technology policy resolutions adopted since independence. While underlining the mechanism of state funding of science research in our country, it has drawn an analogy with the same in the United States.*

**Keywords:** Inclusive growth, innovation, science funding, science policy.

SCIENCE unravels the mysteries of the universe and widens the horizon of our knowledge. A scientist undertakes a sojourn on an uncharted path to realize the truth; his journey is always challenging, but at the same time rewarding. While broadening human knowledge, science makes our life comfortable by application of this knowledge through technology development. Technology instills a new strength and confidence in the struggle of a common man for improving the quality of his life. Science and technology provide solutions to the challenges which the civilization faces as it progresses. Thus knowledge of science becomes the most important capital in nation-building.

Research and development (R&D) in science requires patronage. This is universally true. This patronage comes from the state, from a section of the affluent having commitments to bring in societal good through application of science, from industry under an imperative urge to improve the quality of the products or to evolve new products in a competitive market. The extent of support coming from each of these different sources varies from country to country and also in accordance with the demand of the hour.

For example, the history of development of science and technology in the United States shows that during the two world wars, or more specifically, during the Second World War, the Federal Government took far greater initiative in R&D in science and technology, in mission projects in defence laboratories or in their university laboratories under the pressing demand of evolving a particular technology for war purposes. In this regard we may remember the contribution of the Manhattan Project in the successful development of the atom bomb. In fact, from that time the Federal Government took the leading role in encouraging R&D in the university laboratories through what is known as the 'contract system', which is still in vogue. The development of radar technology in the radiation laboratory of MIT is an example. In the period prior to the Second World War, private trusts and foundations like the Rockefeller Foundation, the Carnegie Institution played a pioneering role in encouraging scientific research in the university laboratories.

In our country also, prior to independence, it was the magnanimity of a few well-to-do visionaries that laid the foundation for scientific research. In this connection we may recall the contributions of Mahendralal Sircar, the famous allopath-turned-homeopath who had treated Sri Ramakrishna, in setting up the Indian Association for the Cultivation of Science in Kolkata in 1876. We recall with gratitude the contributions of another visionary – J. N. Tata – in setting up the Indian Institute of Science at Bangalore in 1909. Along with the creation of these facilities, in pre-independent India, foundation of scientific research was laid in a few college and university laboratories with financial support extended by some wealthy, noble souls with a positive attitude towards science. Thus, at the initiative of its Vice-Chancellor Asutosh Mukherjee, higher education and research in a few disciplines like physics, chemistry, mathematics commenced in the University of Calcutta in 1917, with generous financial support received from notable persons like Taraknath Palit and Rashbehari Ghosh. The situation drastically changed after independence.

For building up a self-reliant and prosperous India, the Planning Commission was set up in 1949 for drawing up Five-Year Plans and also for coordinating the activities among different Ministries/Departments for implementation

Dipankar Mukhopadhyay is in the Satyendranath Bose National Centre for Basic Sciences, Block JD, Sector-III, Salt Lake, Kolkata 700 098, India. *e-mail: atisdipankar2003@yahoo.co.in

of these plans. In the initial years, outstanding scientific personalities like Homi Bhaba, Prasanta Chandra Mahalanobis, S. S. Bhatnagar, Jnan Chandra Ghosh, Vikram Sarabhai, D. S. Kothari played a prominent role in charting the roadmap of R&D in science and technology for the new nation. It was at the instance of Bhaba that the Tata Institute of Fundamental Research was set up at Mumbai in 1945 and the Atomic Energy Commission in 1948. A separate Department of Atomic Energy came up later in 1954. The Council of Scientific and Industrial Research (CSIR) was set up in 1942 as a registered society. During the First Five-Year Plan (1951–56), this organization played an important role in the setting up of a chain of laboratories for carrying out industrial research in different parts of the country and thereby laid a solid foundation for achieving self-reliance in science and technology[1].

At the instance of Mahalanobis, the architect of the Second Plan (1956–1961), a panel of scientists was set-up for advising the Planning Commission. The Scientific Policy Resolution, 1958 was adopted at this time. In this Resolution, technology was acknowledged as the most important capital in nation-building. It was appreciated that the technology evolves out of acquisition of scientific knowledge and its application. It was also appreciated that the full potential of our human and natural resources could be effectively utilized only through industrialization; but for such industrialization, it was necessary to educate our human resource in science and also to improve their technical skill through training. It recognized that science, through widening the horizon of our knowledge, enriches the value system of life and provides new dynamism in the march towards progress and prosperity. A commitment was, therefore, given in this Policy Resolution to encourage teaching and research in science in all its forms – basic sciences as well as applied – in an unfettered environment, to ensure an unhindered supply of scientists of the highest quality and to recognize their contribution in nation-building. The fruits of this Policy became evident soon during the Green Revolution, when India emerged self-sufficient in foodgrains production, during the White Revolution when the country emerged as the highest producer of milk and milk products; in atomic energy, space science, heavy industries, etc. when India emerged as a major power.

During the Sixth Plan period (1980–85), a Science and Technology Cabinet Committee was set up in 1981 with the Prime Minister as the Chairperson. Further, a few new ministries/departments/agencies connected with science and technology came into existence during this period like the Department of Environment, the Department of Ocean Development, the Department of Non-Conventional Energy, the Ministry of Science and Technology (the Department of Science and Technology came into existence earlier in 1971), the National Biotechnology Board. A Technology Policy Statement was adopted in 1983. Utmost emphasis was given in this Policy Statement on attaining technological self-reliance, which would relate to people's aspirations, and development of need-based appropriate indigenous technology which, through optimal utilization of human and natural resources, would bring in qualitative improvement in the life of common man, as well as ensure faster development of the disadvantaged areas and weaker sections of the society. According to this Policy Statement, the choice of technology should address the problem of regional inequalities, make a dent on poverty and unemployment, enhance productivity with efficiency and with optimal use of energy without upsetting ecological balance. Attaining technological self-reliance to be internationally competitive through innovations and inventions and full use of traditional skill and installed capabilities, as well as through setting up of R&D units in industry was the thrust in this Policy document, which was adopted in the backdrop of international pressures arising from Pokhran nuclear blast in 1974. The implementation of the Policy yielded positive results in attaining self-reliance in rocket/missile technology, weather forecasting through installation of satellites, indigenous development of chemicals and pharmaceuticals, etc.

Again, in 2003, in the context of globalization through rapid stride in information technology and emergence of a keen competitive world situation, a new Science and Technology Policy was adopted. In this Policy Statement utmost emphasis was given to attracting our best talents in the arena of scientific research by providing a new package of financial incentives to researchers in fundamental sciences, as well as through assured career opportunities, boosting investment in R&D up to 2% of our GDP by the end of the Tenth Plan with enhanced contribution from the industry, rejuvenating our scientific establishments by providing them utmost autonomy and through a continuous process of review and reform of their academic and administrative structures, strengthening our college and university laboratories, removal of poverty, hunger and malnutrition and creation of employment through science and technology, greater integration of inputs from R&D with programmes in socio-economic sectors, creation of world-class facilities in carefully selected centres and nationally relevant fields, creation of a synergy between industry and academic institutions through transfer of knowhow, fund-support mechanism, etc. providing new fiscal incentives for augmenting investments in R&D, building up of scientific knowledge for prediction, prevention and mitigation of natural hazards, making intellectual property rights regime attractive to innovators, participation in world consortia of scientific research collaborations in relevant areas, enhancing the development and export of high technology as well as high-tech products from the country, etc. The new Policy was adopted in the backdrop of economic liberalization launched in our country in 1991, to ensure that we could retain and even improve our prime position as continuous innovator and creator of science and technology intensive products in the knowledge-based world. This Policy brought in its wake a whole plethora of research fellowship programmes to encourage our young scientists in the pursuit of research like J. C. Bose Fellowships, Ramanujan Fellowships, Fellowships under INSPIRE scheme. The period also saw the opening up of integrated Ph D programmes in existing as well as newly established centres of science education and research.

In January 2013, during the Centenary Session of the Indian Science Congress held in Kolkata, the Science, Technology and Innovation Policy, 2013 was released. The need for a new Science Policy was being felt strongly to respond to the rising aspirations of the people. As the Approach Paper to the 12th Five-Year Plan highlighted '… this calls for a well-enunciated Science, Technology and Innovation (STI) Policy, which is supported by an ecosystem that addresses the national priority for inclusive and acclerated growth'[2]. The felt need of the hour has been innovative deployment of technology to find solutions to the national problems. The President of India had already declared the second decade of the current century as the 'Decade of Innovation'. The National Innovation Council had already been set up to give a push to designing and developing a structured innovation ecosystem. The Planning Commission set up an Expert Group of front-ranking scientists to deliberate on the 12th Plan Approach Paper and to concretize the concepts on the anticipated role of the science and technology sector during the 12th Plan.

The Expert Group recommended[3] a two-pronged approach of balancing the social contract of this sector by providing grassroot solutions in nationally relevant areas through focused research and at the same time gaining global leadership in some areas of science through achievement of highest scientific excellence. The Expert Group listed the aspirational goals of the nation to be able to address the problems of energy, food and nutrition, health care, potable water, etc. through innovative deployment of science and technology. The strategy would be active participation and ownership of its diverse stakeholders. The Expert Group emphasized a change in mindset in favour of acquiring global leadership, to educate ourselves through learning from how we had overcome some of the challenges in the past through futuristic planning and concerted efforts, a change in approach to do outcome-driven rather than input-based planning in science and technology. The Expert Group recommended creation of an enabling environment through structural changes in rebuilding and transforming our existing scientific institutions, enriching the human-resource base as well as expanding the same through enlarging the size of the catchment area and harnessing a pool of talent of budding scientists, setting up of new, world-class, publicly-owned and privately managed institutions, putting in place high-class instrumentation facilities, etc. The methodology, in terms of the recommendations of the Expert Group, would be to enhance the outlay for science and technology, adopt public–private partnership in a few mission-mode projects, enhance academy–research institutions–industry interface through appropriate policy interventions, evolve special mechanisms to support centres of excellence/outstanding schools, consolidate the benefits of R&D outputs from both strategic and non-strategic sectors, etc.

The recommendations of the Expert Group had been by and large accommodated in the Science, Technology and Innovation Policy, 2013. According to this Policy document, the Science, Technology and Innovation (STI) system would be central to our national development; there would be a symbiotic relationship between the STI system and our socio-economic sectors; the STI system would be for the people and the Indian society would be its major stakeholder; innovation would be for inclusive growth ensuring access, availability and affordability of solutions to as large a population as possible; that the vision would be to accelerate science-led solutions for faster, sustainable and inclusive growth. At the same time the document envisages India to be among the top five global scientific powers by 2020.

The document proposes spread of scientific temper across the entire population and empowering stakeholders for local actions, enhancing the skills of our population, attracting students at the entry level to a study of science through school-science education reforms like improving the curricula and teaching methods and motivating science teachers, making careers in science attractive for bright minds, providing special incentive mechanism to stimulate research, multiplication of inter-university centres, establishing world-class infrastructure for R&D for attaining global leadership in some select frontier areas, participation in international projects, etc.

The Policy paper targets R&D investment to reach the level of 2% of the GDP (from the present level of 1%) in next five years, with the private sector contributing 50% of the same from its present share of 30% in total R&D investment. This is necessary so that India's share in scientific publications is doubled by 2020 from its present (2011) share of 3.5% of international publications and its present share of 2.5% in top 1% publications is quadrupled by that time. To facilitate private sector investment in R&D, the Policy proposes the setting up of a National STI Foundation on PPP mode, so that the private sector can access public fund for R&D for social and public good. It also proposes risk-sharing by the Government for seeding science and technology-based high-risk innovations by private or public agencies.

The document proposes demand-based R&D interventions in ten sectors of high-impact potential; integration of R&D policy in agriculture with STI Policy and increasing R&D intensity in manufacturing and service sector for increasing our share in high-tech products. The document further proposes creation of a new type of partnership between academia–research–industry so that experts can move with ease from one to another, new auditing principles based on processes and outcomes rather than procedures, prioritizing critical R&D areas like agriculture, energy, water management, health and drug discovery, environment and climate change, materials and flow of STI outputs to socio-economic sectors.

The concept of applying the results of research in science and technology in our socio-economic sectors was mentioned in the Science and Technology Policy, 2003 as well. This is an important proposition, the significance of which is yet to be fully appreciated. Under the existing practices, in our socio-economic programmes in different sectors, there is not much scope for providing technical inputs, which are so important. As a result, many programmes are implemented without much consideration of their impact on the environment or their sustainability. For example, under social forestry programme, often wrong species of plants are chosen, which are not suitable for that particular area. For lack of proper scientific advice, it is often found that two government departments are working at cross purposes, e.g. it has been seen that while the Water Resources Development Department has been asking for preservation of groundwater, the Agriculture Department of the same Government has been encouraging further extraction of groundwater for increased production of a water-intensive crop. Under the Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA), the priority should be on enhancing agricultural activities so that productive employment is generated on a sustainable basis; but this focus is often missing. Since the District Planning Committee (DPC) is a Constitutional entity, there has to be an assured arrangement for it to be advised by a competent technical committee in the matter of drawing up as well as implementation of plans/programmes for socio-economic developments. Only then will it be ensured that these programmes do not remain as just endowments for distribution of doles, but as means for empowerment of the people. At the same time it is felt that our scientific community must be invited to play a more prominent role in socio-economic policy formulations, both at the centre and in the states. We may recall that it was at the insistence of Meghnad Saha, the legendary Indian astrophysicist, that India's first multi-purpose river valley project – the Damodar Valley Corporation Project (DVC) – was taken up. The various State Councils of Science and Technology have to play a more active role in encouraging the process of evolution as well as adoption of need-based technology, so as to provide area-specific solutions to problems.

It is worth mentioning that as in the US, we have a similar system of providing Government funds in R&D through multi channels. For example, ministries/departments like the Atomic Energy, Space, Ocean Development, Agriculture, Defence, Non-Conventional Energy, Environment, Science and Technology, Health provide funds in the budgetary process to their own agencies or others within the broad framework of the Science Policy discussed above, similar to mission-mode projects in the US. The National Science Foundation (NSF) came up only in 1950 in the US. Though this was conceptualized to be a central coordinating agency for all state-funded research activities, agencies like the Atomic Energy Commission (1946), National Institutes of Health (1930), National Aeronautics and Space Administration (1958), defence research establishments remained outside the purview of the NSF. Thus, NSF remains a much weakened entity and the earlier practice of State funding of scientific research in a pluralistic mission-oriented manner continues. In the US, a statement of national policy for science and technology came much later, only in 1976, in the form of an enactment – The National Science and Technology Policy, Organisation and Priorities Act. Along with the enactment, the Office of Science and Technology Policy (OSTP) was established within the executive office of the President and the Director of OSTP was to serve as the President's Science Adviser[4]. In the United Kingdom there is an Office of Science and Innovation in the Department of Business, Innovation and Skills for deciding on Government funding for scientific research under the Foresight Programme. There is a Government Chief Scientific Adviser and individual Government Departments have their own Chief Scientific Advisers. Comparable to this is our Science Advisory Council to the Prime Minister and Scientific Advisory Council to the Cabinet.

However, the industries or the private sector participation in R&D as well as the total investment in this is far greater in many advanced countries compared to ours. We are probably yet to be fully convinced that an expenditure in scientific research must not be looked upon as just another expenditure, but as an important investment for the future. Whereas India's R&D spending was 0.9% of the GDP in 2011 with private sector contribution only around 30% of total expenditure; for Japan it was 3.67% of GDP with private sector contributing as much as 76% of the same; for the US it was 2.7% of GDP with private sector contributing 67%; for Germany it was 2.3% of GDP in which private sector contribution was 66% in the same year. Thus, in India, while it was the private trusts and endowments which played the pioneering role in encouraging higher studies and research in science in the pre-independence period, it is the Government that has been the major fund provider since independence. The situation has to improve if we are to catch up with the advanced countries. The private sector must boost investment in R&D. Time has come for establishing long-term collaboration between industry and our scientific establishments for R&D.

There is some controversy regarding the extent to which the state sector should provide funds for basic research. Since the corpus of the state is always limited and there are competing demands from other sectors, and since state funds are collected through imposition of tax on common man, there is a view that spending from the state exchequer for basic research has to be productive in the sense that it should lead to evolution of appropriate technologies for addressing societal problems. This is a narrow view of things, as the impact of basic research may not be immediately perceptible. In this respect we may recall that the investigations of Einstein and Satyendranath Bose led to the prediction of the existence of Bose–Einstein condensate in 1925; but it was detected and photographed by Ketterle only in 1995. It is always difficult to decide how the efficiency of such funding be measured, just as it is wrong to determine it wholly in terms of the quantity of the research output rather than the quality.

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