Science, Technology and Innovation Policy 2013: outline of a coherent strategy for translating it into action

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Science, Technology and Innovation Policy (STIP) 2013, announced in January 2013 during the centenary session of the Indian Science Congress held in Kolkata, declared in no uncertain terms that the science, technology and innovation (STI) system would be the driving force for a faster, sustainable and inclusive economic growth of India. In the past we have witnessed successful applications of science and technology (S&T) in addressing societal problems in India, in the Green Revolution, the White Revolution and in space and communication science to name a few. This has helped improve the quality of life of a large part of our population and strengthened our economic independence. We have also before us, the examples of war-ravaged Japan, which resurrected its economy post World War II and systematically went up the technology ladder by virtue of its reliance on strength of S&T. In the recent past countries like South Korea, have emerged as technological giants in the competitive world. In this backdrop, our new STIP appears to be most appropriate. It is absolutely necessary to launch policy initiatives simultaneously in different spheres to create an enabling environment for successful implementation of the different aspects of this STIP. This article attempts to draw an outline of such a coherent strategy.

Keywords: Coherent strategy, citation impact, Science, Technology and Innovation Policy.

Focal theme of Science, Technology and Innovation Policy, 2013

SCIENCE and technology (S&T) has always been the most important capital in nation-building everywhere. As such, policy-makers attempt to align S&T from time to time along emerging national and societal priorities through policy statements on the same.

The thrust of the Scientific Policy Resolution, 1958 was on capacity-building in advancement of science as the foundation for making a strong nation, which had just freed itself from the shackles of colonial domination[1]. The focus of the Technology Policy Statement, 1983 was attainment of technological self-reliance and building of national strength by reducing vulnerability in strategic areas[1]. The Science and Technology Policy, 2003 launched a massive programme for attracting our best talents to the arena of research in basic sciences, so that India continues to earn respect in a competitive knowledge society[1]. The Science, Technology and Innovation Policy (STIP), 2013 has put our science, technology and innovation (STI) system as the driver for faster, sustainable and inclusive growth[1]. The latest policy envisages creation of a new STI ecosystem, which finds solutions to societal problems and facilitates the entire innovation chain from knowledge to wealth creation, while at the same time attracting best students to this area, ensuring a premier position for India in the scientific world.

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A few probing questions on the challenges involved for translation of STIP 2013 into action

Now, what are the challenges of translating the above policy into action? Obviously, STI is 'no magic wand to wave over a poor country to make it a rich one', as mentioned by Lord Blackett[2]. The STI system does not operate in vacuum. There has to be an enabling environment so that it can function effectively, efficiently and enrich the society at large through its contributions. For making STIP 2013 functional, we may need to ask ourselves the following questions:

- Do we have a specific, coherent and result-oriented scientific strategy to make the Policy functional?
- Do we have an effective mechanism for integration of science into the larger process of governance, development and nation-building?

- Do we have a system in place to lend itself as an interface between science and its end-users?
- Are our industries, particularly the small and medium industries, sufficiently keen and proactive to upgrade their performance and competitiveness by collaborating with universities and research institutions for technology transfer and in the process to boost the research and development (R&D) activities of the latter?
- Do we have institutions in place to facilitate interactions between our universities/research institutions and industries, or do we require intermediaries to bridge the gap?
- Do we have a proper arrangement in place for skill formation for our abundant unskilled work-force to cater to the needs of a modern economy?
- Do we have an innovative approach in our school curricula to significantly impact the choices of our talented youngsters so as to draw them towards a career in science? Or do we suffer from systemic deficiencies like lack of good teachers, absence of modern pedagogy, etc?
- Is our school and undergraduate education system providing the required problem-solving orientation to our young minds and generating sufficient curiosity in them to choose a career of research and innovation? Or is there a dichotomy between teaching and research?
- Is our incentive mechanism in scientific research and academics adequately rewarding to attract and retain the interested young talents in their respective fields of choice in science and technology?
- Have we got our research system where it needs to be? Should we have more mission-oriented approaches, tied to strategic planning and sound economic cost-benefit analysis?
- Is the current evaluation mechanism of publicly funded research system in line with the new Policy or should we insist upon a more demonstrative economic and social impact of such research?
- Is the society at large sufficiently enlightened to recognize and honour the professionals in research and academics, which they deserve, or should conscious steps be initiated to instill this sense of value-judgement in our people?
- Do we have a vast and effective network of popular science initiatives to spread the message of science across the population or are massive efforts for inculcating scientific spirit needed so that people start appreciating the value of science in improving the quality of their lives?
- How effective are the State Councils of Science and Technology in evolving area-specific need-based technologies?
- Above all, is the present available funding for research, particularly the public-sector funding, adequate to make our STI system strong enough to lead the nation to a robust economic growth?

Here we examine some of these issues and suggest how to overcome these challenges so that our STI system is strengthened to assume the leadership role it has been envisaged to play in STIP, 2013.

Making school science education attractive and inspiring

STIP, 2013 lays emphasis on attracting students at the entry level to study science through education reforms at the school level, like improving the curricula and teaching methods, motivating science teachers, etc. This is a challenging task indeed. In many schools in rural areas facilities like science laboratories do not exist. Also, many schools in remote areas do not have affiliation for teaching science at plus-2 level, as they do not have adequate number of classrooms. In a situation like this, the resultant gender exclusion is quite significant. How to ensure access to quality science and mathematics learning opportunities in our remote schools so as to ensure supply of our R&D personnel from varied socio-economic backgrounds in a country like ours, with 70% of the population living in villages, is an enormous challenge. The National Knowledge Commission (NKC), in a letter to the Prime Minister in May 2008 (ref. 3) pointed out, 'Countries like China and South Korea, having invested prudently in science education are now beginning to reap rich dividends'[3]. In India, availability of good teachers and absence of modern pedagogy are the key limiting factors for schools and universities to make science and mathematics exciting[3]. NKC had also issued a warning signal, 'India's growing backwardness in science and mathematics will eventually retard its ability to be globally competitive and affect its economic growth and social well-being… Only a massive, well co-ordinated and well-funded national initiative, sponsored at the highest level, can begin to bring about a mindset and attitudinal change in India towards science and maths teaching and research.'[3] NKC recommended a mission-mode approach with a master plan and a core team of 40–50 bright Indian scientists and mathematicians, to promote creation and disbursal of quality science educational materials and teaching aids, to facilitate development of courses in line with recent developments in science and emerging employment opportunities, to plan, execute and supervise a nation-wide in-service science-teacher training programme, to organize academia–industry meets and discover novel ways of participation in science-related activities by industry, etc. (Annexure I to the May 2008 letter). It is an emergent imperative that some positive steps are taken to implement these recommendations without further delay.

Removing the dichotomy between teaching and research to widen the catchment area for research

In our country we have established a large number of research institutions and our undergraduate colleges and

universities are now by and large engaged in teaching activities. Thus, we have created a dichotomy between teaching and research at the cost of research activities in our universities. NKC once again, in another report has observed, 'Throughout the world, universities are the natural home for the interface between teaching and research. But this is far from reality in the vast majority of Indian universities…Dedicated researchers involved in direct training of the students at the undergraduate level create a greater impact…. It is now increasingly being recognized that separation of research and teaching has been at the cost of creating a good research environment in the universities; …..research culture be brought back to our universities through focused engagement towards making universities a natural home for research as well as teaching.[4]' NKC has emphasized the need for establishing mechanisms for greater academic collaboration between universities and research institutions, like sharing of resources, teaching in universities by research scientists as visiting professors, greater exposure of undergraduates and postgraduates to cutting-edge research, establishing dedicated science teacher training centres at research institutes/universities for advanced-level courses[5], embedding research institutes (by granting sufficient autonomy) within university campuses[4], etc. These proposals, if implemented, will widen our R&D base.

Recently some positive steps have been taken in this direction by the Department of Science and Technology (DST), Government of India (GoI), through issuance of a circular that every scientist under its research establishments must participate in outreach programmes for a minimum number of 12 h in a year. This initiative, if implemented properly, would provide a forum to establish a link between reputed scientists and students pursuing different undergraduate/postgraduate programmes. The Ministry of Science and Technology (MOST), GoI, has launched a special scheme for Promotion of University Research and Scientific Excellence (PURSE), which is providing incentive grants to universities based on their research performance. This has started to yield good dividends, both tangible in the form of increased research publications by the universities, and intangible in the sense of creating an appropriate mindset for research between university students and teachers.

Providing attractive financial incentives to researchers to attract and retain the best talents in scientific research

It is of prime importance that the financial incentive package for our researchers is made sufficiently attractive to draw and retain young talents in the area of scientific research of their choice. This is all the more important, considering the fact that a vast majority of them come from middle-class or lower middle-class families and have pressing family commitments. In quite a few cases we have researchers from families of first-generation learners, which is a matter of encouragement for us. In many cases, researchers coming from poor families are constrained to partly support their families from their research fellowship funds. In fact, instances are not rare in extreme cases when pressing family commitments as well as the prospect of job security have lured the researchers away to permanent jobs elsewhere. They have thus sacrificed their promising research careers, which is a profound loss to science. While serious attempts have been made to address this problem through schemes like providing fellowships under 'Innovation in Science Pursuit for Inspired Research (INSPIRE)', which have been providing some amount of financial security to our scholars, the situation calls for urgent steps for further rationalization.

To illustrate the point, let us consider the latest revision in Research Fellowships – Junior and Senior (JRF/SRF), effective from 1 October 2014, by DST/Council of Scientific and Industrial Research (CSIR)/University Grants Commission (UGC), raising the scholarships to Rs 25,000 per month for JRF and Rs 28,000 per month for SRF, from Rs 16,000 and Rs 18,000 per month respectively. In addition, both JRFs and SRFs get an annual contingent grant of Rs 20,000. If we compare this with the emoluments of an M Sc and NET-qualified Assistant Professor on a UGC initial scale of Rs 15,600–39,100 per month with a grade pay of Rs 6000 per month (effective from 1 January 2006) plus dearness allowances (DA), etc., the starting emolument itself was at least Rs 6000 more per month than that of a JRF, prior to the latest revision of the latter's fellowship. In addition, if we take into account the impact of grant of DA, when it became 107% by December 2014, a new Assistant Professor, would get Rs 15,600 plus grade pay Rs 6000 plus DA Rs 23,112 per month, total being Rs 44,712 per month, ignoring other allowances. Compared to that, a JRF with the same postgraduate qualifications would get only Rs 16,000 per month (prior to revision), and post-revision only Rs 25,000 per month. The difference is quite significant even after revision to lure away a researcher from a poor family background. Thus it is of paramount importance to be a bit more generous towards our research scholars, so that they may concentrate on their research work and give their best to the country.

It is, therefore, proposed that there should be complete parity between the starting emolument of an Assistant Professor on a UGC scale, taking into account his basic plus grade pay and that of the JRF. The fellowship should increase annually at par with the DA installments announced to compensate for the inflation or annual increase in the price levels, or at least by an average of 10%, judging the present trend of annual DA increase. The annual contingency grant should not be disturbed. Instead of the present system of revising the fellowships on an ad-hoc basis, it is suggested that the revision of

fellowships should be co-terminus with the revision of UGC pay-scales. This proposal for providing parity is being mooted with the expectation that it would ensure some amount of financial stability to our research scholars vis-à-vis their counterparts on regular scales.

It needs hardly any mention that these bright scholars in research are investing their prime years in the pursuit of science. They could have joined much more lucrative jobs elsewhere, but for their love of science. As such it would only be fair to find various alternative avenues to compensate, to the extent possible, the financial losses they have willingly agreed to suffer for the pursuit of knowledge. These options may be to offer them teaching assistantships, creating as many attractive berths with desired facilities as possible for postdoctoral fellows (PDFs) like fruitfully utilizing them in universities or industries, treating postdoctoral experience as equivalent to teaching experience in making university appointments, etc.

STIP, 2013 flags a few ambitious targets like India to emerge among the top five scientific powers by 2020, our share in international scientific publications to get doubled from the present level of 3.5% (2011), and the present share of 2.5% in top 1% publications to get quadrupled by that time. However, it is disturbing to observe[6] that India's R&D expenditure at current prices as a percentage of GDP has been hovering between 0.75 and 0.88 over the period 1990–91 to 2011–12. This is a dismal figure compared to the present (2012) level of gross expenditure in research and development (GERD) figures as a percentage of the respective GDPs of countries like Japan (3.5), Germany (3.1), South Korea (3.5), USA (2.8), etc.[7]. While the industry and private sector in these countries contribute 60–70% to the research expenditure unfortunately the share is around 30% only in India. STIP, 2013 targets the share of the private sector to go up to 50% of the total expenditure in R&D in the next five years to take the GERD to GDP percentage to 2. While it cannot be overemphasized that the private sector in India must increase its R&D expenditure for transformation of the country to a knowledge-based economy, the state sector cannot but continue to play a leading role in promoting research in spite of the resource constraints and so increased investment of the state sector in this is called for. After all, the STI system needs to be strengthened if it is to strengthen the economy of the country.

Creating an enlightened society through scientific temperament

There is no denying that we have a lop-sided societal value-system prevailing all around, where mediocrity runs the show and talent is rarely recognized. The back-breaking silent work of a scientist remains unnoticed, while the print and electronic media remain engrossed with stories of skillful manipulations by the self-seeking coterie of corrupt politicians and crafty bureaucrats. The moribund society feeds on these stories. Finding no glimmer of hope for the future, people by and large get further demoralized. They lose their initiative for ushering in a better future through nurture and rational application of their intellectual faculty. They thus sink into further degradation, while a few continue to prosper, just like parasites, at the cost of ignorance of the vast multitude.

The spreading of scientific spirit in every nook and corner can only remedy the situation and make our population aware of the wonders that a scientifically enlightened population can achieve. Our national media agencies like the All India Radio (Akashvani), Doordarsan, and Prasar Bharati have to play a leading role in popularizing science across the population and in bringing the contribution of our scientific community in nation building to the limelight, so that our people are made aware of it and start recognizing their contribution. Our scientific community is to be invited regularly to participate in science popularization programmes, in scientific debates and discourses, etc. in popular media. Analogy may be drawn from the excellent role our national channels in radio and television have been playing over the years in popularizing the great heritage in our classical music, wherein we find the true soul of our nation – as fresh and vibrant as it has ever been. They will have to play an even more active role in the spread of scientific temperament throughout the length and breadth of the nation, to rescue it from the morass of desperation and self-pity. As Menon[8] puts it, 'Science is to be an integral part of all our activities'. That will go a long way towards creation of an enabling environment for fostering a new STI ecosystem in the society at large, when merit and not money power will be respected.

The State Councils of Science and Technology have a great role to play in taking science closer to the people. Their function should not just be limited to sanctioning funds against a few proposals for localized technological interventions and observing Science Day annually. They have to emerge as an effective forum for spreading the message of science in every nook and corner.

Effecting linkages between the STI system and the socio-economic sectors

It is absolutely necessary that an effective linkage is established between our STI system and the socio-economic sectors at different levels, so that populism and ad-hocism in drawing and implementation of different policies and programmes are avoided. This is also necessary to take a rational decision in the face of competing demands on scarce natural resources in the interest of adopting a growth strategy, which is sustainable. It is not sufficient to have a few scientific advisors at the apex

level and a few scientific personnel heading a few departments. While the Scientific Advisory Council to the Prime Minister or to the Cabinet or experts in the erstwhile Planning Commission (now NITI Ayog) have played and will continue to play a valuable role in sensitizing the Prime Minister or the Cabinet towards S&T or in apprising complex project proposals, it is necessary that we create similar forums at different socio-economic ministries/departments, both at the centre and at the states, and also in block and district planning committees with adequate funds, functions and functionaries. It has to be ensured that these do not remain as just recommending bodies with the chances of the politico–bureaucratic nexus having the final say in overruling such recommendations. The rising experience of absolute misuse of authority in launching popular programmes, looking solely at the vote bank and ignoring everything else, at the expense of public money with absolutely no economic returns, makes it all the more imperative to bestow some sort of constitutional sanctity to such interacting forums so that the experts can moot new proposals, evaluate the merit of a proposal, monitor the implementation and carry on the post-implementation assessment fearlessly. Obviously, such forums are to be sufficiently strengthened with adequate number of experts from different disciplines, who may be drawn from the scientific community on deputation for a certain number of years.

Tuning our research system to societal aspirations

While our past experience shows that the faith we have all along reposed in our scientific capability and our increased investment in S&T have paid rich dividends, we also need to accept that there is an imperative necessity for the STI system to be more tuned to the societal aspirations. It is encouraging to observe that during the 5-year period 2006–2010, India's scientific publication output grew[9] at a compound annual growth rate (CAGR) of 12.3% per year, while the world publication grew at 4%; the publication of only two countries grew faster than ours in the said period – China at 13.7% and Iran at 25%. Our publication in the energy sector grew at 13.3% CAGR. Publications in each of these sectors – material science, physics, astronomy and medicine grew at more than 7% per annum in the said period. India's overall citation impact in 16 major scientific fields improved to 0.68 during the period 2006–2010 from 0.58 during the preceding period 2002–2006. In a few disciplines it was above world average, e.g. energy (1.26), chemical engineering (1.18), engineering (1.04) and materials science (1.01). According to Bhattacharya and Kaul[7], our return to investment in research measured as publication intensity as percentage of GERD is high, showing India spends the least amount per paper compared to countries like USA, China, Japan, South Korea, France, Germany, UK, etc. in scientific publications. All these are eloquent testimony to the high quality of our scientific manpower.

At the same time we are faced with varied problems in such diverse sectors as energy, environment, climate, natural resources like soil and water, food and nutrition, health and hygiene and so on, affecting the quality of life of our population. Our STI system has to address these issues, if we are to do science in a sustainable way. Our scientists cannot close their eyes to the problems encircling them outside their laboratories. While doing research in the frontier areas, our scientists have to find solutions to these problems. In this connection we may recall what Menon[8] had said years back: 'It is interesting that all of these problems that Pasteur encountered were in his immediate vicinity and interest in them evolved from his own basic research in which he displayed great experimental ingenuity. His approach was fundamental and resulted in the formulation of new biological principles. We have only to look at the range of problems that we encounter in our environment…to realize that there are challenges to excite the keenest minds.' Our research initiatives need to be more focused like what Vikram Sarabhai, while drawing up the country's space programme, had suggested that sound economic evaluation of the required resources was necessary before embarking on the programme. Sarabhai saw an opportunity in space science and technology to leap-frog from its backwardness and poverty. Like our Nano Mission and a few others, we may consider to take up time-bound mission approach in more select areas. Once again we may quote Menon[8] 'Some deliberate measures are called for to see that the best and well-trained among them (student community) are provided adequate incentives to take up research as a career and that areas are defined and supported that best serve national interests and priorities towards which such talent can be directed or encouraged to work on.'

Accelerating private sector participation in R&D

In the pre-independence period in India, the private sector and trusts played a pioneering role in promoting science. We recall with gratitude the contributions made by persons like Mahendralal Sircar in establishing the Indian Association for the Cultivation of Science in Kolkata in 1876; J. N. Tata in establishing the Indian Institute of Science in Bengaluru in 1909, Taraknath Palit and Rashbehari Ghosh in establishing postgraduate science departments in the University of Calcutta in 1917, etc. The situation drastically changed in independent India. We find from the R&D statistics of 2011–12 that private sector R&D expenditure as percentage of sales turnover was significant only in a few sectors like biotechnology (3.85), drugs (3.45), information technology (5.47), transportation (1.26) and scientific instruments (2.66)[6].

As in 2009–10 we find substantial private sector investment in industrial R&D only in a few sectors like drugs and pharmaceuticals, transportation and information technology[10]. Obviously, for translating the vision of STIP 2013 our private sector is required to accelerate investment in R&D.

To explore how to do this, DST appointed a Joint Committee of Industry and Government (JCIG). This Committee submitted its recommendations in May 2013. Among other things, the Committee suggested[11] a few measures to incentivize commercialization of R&D, providing financial support on R&D risks and failure management (for which the model of Israel and Singapore may be consulted), providing dedicated sector-specific funds by the Government and industry on 50 : 50 basis for building technology depth in five priority sectors like transportation, electronics, pharmaceuticals and biotechnology, minerals–materials–metallurgy, next-generation manufacturing technologies, heavy industries as well as providing area-specific dedicated funds on similar lines for investments into PPP for developing and deploying technological solutions in five national priority sectors like affordable health care, renewable energy, water treatment/purification, sanitation and waste management, etc. Presently, industry is doing in-house R&D and also collaborating with research institutions. More such long-term collaborations with the state sector are needed with free flow of resources from one to another for creating a more congenial R&D ecosystem.

Concluding remark

The vision of STIP 2013 is that the society at large shall be the stakeholder of our STI system, which is to reach as many persons as possible to provide answers to societal problems, while at the same time the country emerging as one of the top five global scientific powers by 2020. The realization of this vision implies adoption of a coherent and focused strategy, encompassing every aspect of our life and thinking. An outline of such an omnibus strategy has been attempted in this article.

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