Science, Technology and Innovation Policy in India under Economic Reform: A Survey

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INTRODUCTION

In the pre-economic reform era, the question of scientific and technological development in India had a central role in the general debate on the country's development strategy, whether in policy-oriented discussions, in academic considerations or in discussions in the public and political arena. Unusually, compared to several other contentious issues, science and technology was the subject of a rather broad consensus that, barring a few notable exceptions, drew support from across the political spectrum and from many strands of public and political opinion. The exception was of course the Gandhian critique that originated in a foundational critique of industrial technology and industrial production. But barring this critique it was generally agreed that science and technology were one of the key elements of national economic growth and the general improvement of the material conditions of the population. Indeed the role envisaged for science and technology in national life went well beyond an instrumental view of science and technology in any purely economic view of development. Science and scientific temper were, in a view most elegantly articulated by Nehru, indispensable to the development of a new ethos and world-view that would privilege rationality and a critical attitude.

Scientific and technological development was also closely linked to the paradigm of self-reliance. Whatever the vicissitudes suffered by this paradigm in the sphere of industrial policy, the rhetoric of self-reliance held the high ground in the formulation and implementation of scientific and technological goals and policies. The origins of this link, as is well known, are to be found in the colonial era in the views of the freedom movement. These views saw the possession and control of scientific and technological knowledge as the key both to a significant presence on the world stage as well as the surest way to avoid the perils of economic dependency that characterized the colonial era. The rhetoric of indigenously developed science and technology together with the paradigm of self-reliance framed the policy discourse on science and technology for several decades after the attainment of national independence.

In its early years clearly the rhetoric was in some way matched by the performance of several sectors of Indian science and technology. However the promise held out by this performance was belied by a number of weaknesses. These included the many weaknesses and gaps in the performance of even the sectors that were hailed as the exemplars of Indian S&T. S&T performance clearly failed in part to impact on poverty alleviation and overall development, as the rhetoric of the State had promised. In the 1980s, the increasing distance between the rhetoric of self-reliance and the actual level of technological development and innovation in Indian industry was becoming apparent. Critical discussions of Indian science and technology policy have tended to founder on the issue of assessing this gap between the promise held out by the performance of the early years, and the reality of the performance of Indian science and technology assessed in terms of this very rhetoric.

With the initiation of economic reform, science and technology policy began to undergo a series of significant shifts. In this paper, we will focus on a survey of some key features of India's Science, Technology and Innovation system (STI) that will enable us to examine the extent to which the official optimism with regard to these new policy shifts is justified and the extent to which they have been realized in practice over the nearly two decades since the initiation of reform. We will point, contra the received view, to a considerable gap between rhetoric and performance that in many ways indicates that the Indian STI system is still conditioned by the strengths and weaknesses of an earlier era. Given these weaknesses, the hope that the policy shifts of the reform era will to lead to a new era of widespread innovation and the emergence of a new knowledge superpower seem to be as yet in the far distance.

S&T IN THE PRE-REFORM PERIOD

We begin with a brief, entirely qualitative account of some key issues of S&T in the pre-reform era.

By the 1980s India had already developed a science and technology establishment that had few parallels among developing countries. It had developed over the years since Independence, an advanced scientific and technological infrastructure that included i) a nuclear energy sector with independent capabilities, ii) a space sector that rapidly moved from semi-experimental status to establishing strengths in communications infrastructure, and remote sensing capabilities, iii) a chain of industrial research laboratories that covered a wide range of fields ranging from leather technology to modern biotechnology, and iv) a network of defense research laboratories. In agriculture, India developed a national agricultural research system and an agricultural extension system alongside the Green Revolution that significantly increased agricultural productivity and helped increase the diversity of India's agriculture. In the field of health it established, though more slowly, a system of institutions of medical teaching and research that developed considerable capabilities in several areas of medicine.

The level of technological development varied across different sectors. Over time though Indian industry was able to absorb new technology in many areas, technology that despite being imported in the first instance was nevertheless mastered and adapted and utilized under local conditions.

Higher education in science and technology grew with the establishment of the IITs and a network of other engineering institutions, both of a general and specialized character. Importantly there was a parallel development of a network of Industrial Training Institutes and polytechnics that provided a source of skilled manpower. Basic science capabilities were built across a wide spectrum of disciplines, many of which such as chemistry and molecular biology are the foundations of successful innovation even today.

A decisive move was the passage of the Indian Patent Act of 1970 that moved away from product patents to process patents. This had a major impact, particularly on the Indian drugs and pharmaceuticals industry. The capacities, both in production and knowledge, that were built as a consequence in this sector, play a significant role in India's science and technology scenario even today.

The scientific and technological development policies of this era were of course set within the framework of the general strategy of industrialization of the early Plans and the development of STI infrastructure closely paralleled the development of a strong public sector in industry.[1]

But despite this steady growth, there remained several significant weaknesses that acted as constraints to further growth, weaknesses that were both exogenous and endogenous to the science, technology and innovation system.[2] While we discuss some of these weaknesses in the following we shall not devote too much attention to larger macro-economic issues that are also undoubtedly important.[3]

Another key constraint was the weak linkage between the R&D infrastructure and the system of production. The root cause of this weakness can undoubtedly be traced to the actual practice of the policy of import-substitution. Despite the rhetoric of self-reliance, indigenous development of technology was often an option that was exercised only when faced with outright technology denial. In the early Plan periods when such technology denial had critical implications, the push to indigenous technology development was considerable. However as later developments eased access to technology, the recourse to outright technology purchase was frequent. Technology import restrictions were never a major problem when macro-economic conditions permitted it. Furthermore the debate over import of technology was often phrased, as in the Mudaliar Committee Report of 1966, as a choice between the needs of a diversified industrial base and an inadequate technical base. Thus the need for growth was counter posed to the building of indigenous technical capability and the choice inevitably swung towards allowing technology import.

Given the critical need for the public sector, the bulk of the risk of the introduction of new technology, especially in the area of capital goods and intermediate goods production, was borne by the public sector, while the private sector developed little innovative capabilities in these sectors.

It is not clear what role the R&D infrastructure that was being built, especially in the area of industrial research, played in the matter of the development and diffusion of innovation in these sectors. While some of the CSIR's activities did lead to actual production, this always constituted a small fraction of the full scale of industrial activity. In sectors such as leather successful diffusion of technological capabilities did take place and indeed some commentators have seen CSIR as basically oriented towards small-scale and medium-scale

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1 For a detailed and sympathetic account of STI in these years, see for instance Baldev Raj Nayar, India's Quest for Technological Independence, Vols. 1 and 2.

2 See for instance Amiya Bagchi, Public Sector and the Quest for Self-Reliance, EPW, Vol. 17 (1982) for an elegant critique.

3 One such example is the role of demand constraints in the textile sector that led a shift from mass production of cheaper textiles to high-end textile production and related questions of technology choice.

enterprises.[4] However the CSIR appeared to cover a wide range of technological areas, including areas such as metallurgy, where nevertheless technological upgrading at larger scales inevitably led to the import of technology.

In retrospect one may also add that the basic policy vision that drove science and technology policy appeared to work within the framework of a macro-variant of the linear model of innovation. Science was to play the leading role in the vision, with technology to be developed based on scientific advance and the diffusion of this scientific and technical knowledge to be carried forward, unproblematically, by education, the demonstration of its efficacy and suitable economic incentives. Thus laboratories and institutions were seen at the apex of a hierarchy at the bottom of which was the unit of production. This is clearly reflected in the heroic language of the Science Policy Resolution, which is fully cognizant of the importance of scientific knowledge, but pays little or no attention to the issue of technology and has no view of the complexity of the linkages between science and technology. From the same era comes the Industrial Policy Resolution that is more concerned with the organization of industry and its control, the respective roles of the public and private sector and other such issues.

What appears to be missing in between was a vision of technology, not just as the transmission link between science and industry, but as an independent autonomous activity. There appeared to be little recognition of technology's complex interplay with economic factors on the one hand and the development of its own knowledge base on the other, knowledge that was acquired by a variety of methods and pathways. The example of countries like Japan was often cited in policy documents but such discussions dwelt more on generalities rather than the specifics of technological learning and innovation.

This is not to imply that these issues were not realized in particular sectors, like rubber and leather, resulting in substantial achievements. But the overall vision seemed to have little to say about the specifics of technological advance. As the later half of the 1980s approached, some degree of indigenous technical advance had taken place. But the bulk of it was restricted to areas where technological advance had any way slowed down considerably, allowing an eventual process of catching up to take place.[5] Confronted with newer technologies such as semiconductors, integrated circuits and later silicon chips, Indian innovation capabilities were again not adequate to the task at hand.

Agriculture presented other issues. Early on, it became clear that the Green Revolution would never fulfill the promises of the political rhetoric that accompanied it as it was not complemented by any thoroughgoing institutional transformation such as land reform. Poverty eradication did not follow on the heels of the Green Revolution, thus giving a new lease of life to a conservative critique of technological change in agriculture. But given the magnitude of the success of the Green Revolution it would be appropriate to note that it is perhaps the sector of Indian science capabilities that has delivered the most. Backed by appropriate institutional mechanisms in its heyday, the national agricultural research system

4 Baldev Raj Nayar, op. cit. Vol. 2, p. 382.

5 Or as in heavy water in the nuclear sector, full scale technology denial and the related absence of market pressures and the overriding need to achieve capability did not make time a critical factor.

among all of India's science sectors has perhaps been the closest overall to real productive activity.

The higher education base for S&T continued to be built on a base of widespread illiteracy. At the same time, several factors induced sections highly educated scientific and technological manpower resource pool to move out of India in search of opportunities. Thus some part of India's investment in S&T higher education ended up serving other nations' requirements, particularly the United States.

S&T IN THE REFORM ERA

The onset of economic reform introduced a series of significant shifts in the policy framework for science, technology and innovation. The paradigm of self-reliance in the realm of industrial policy was the first to go. Alongside the rapid dismantling of a wide range of industrial licensing requirements and import regulations, the view that technology development would be driven by the beneficial effects of foreign direct investment and increased trade was eventually installed as official policy.

This is not to imply that the issue of technological development or access to new technologies was at the core of arguments for the setting aside of the self-reliance paradigm. The initial thrust of the reform rhetoric was focused more on the dismantling of the regime of controls and licensing and its implications for technology development and innovation appeared explicitly to be a later concern. Nor do we wish to suggest that the slogan of self-reliance was entirely dispensed with, given its tendency to resurface especially when strategic issues and interests were involved. Nevertheless, official policy clearly moved decisively away from the question of self-reliance towards emphasizing the benefits of India's integration with a global system of production, with the earlier paradigm often being equated with either economic autarchy or cultural insularity.

The second key shift was the increasing acceptance of the global intellectual property rights regime. As India's integration into the global IPR regime progressed, it was argued that this would not curb the competitive capabilities of Indian firms in various sectors and that there were sections of Indian industry that had enough innovation capabilities to hold their own in the global market place. In a related move, it has also been increasingly argued that a strong IPR regime would indeed provide a positive push to innovation in the Indian economy.

The third key shift was the emphasis on the private sector as the key sector to drive innovation forward. In the academic justification of this view, the secondary role of the private sector in research and development of the earlier era is held to be the consequence of the absence of incentives to motivation in the era of the license-raj. In the new era it is argued that innovation would naturally emerge more strongly in the private sector.

The rapid growth of the IT/ITES sector in India through the 1990s and the relatively successful performance in other sectors such as biotechnology and drugs and pharmaceuticals as has in the subsequent decade seen a new policy thrust that argues that India can find a role as a key player in the emerging global `knowledge' economy. In this view, India's comparative advantage lies in it's relatively (compared to other developing countries or even the smaller developed nations) large base of scientific manpower and wide range of research institutions that will be able to undertake R&D activity at significantly lower costs compared to developed nations. The new opportunities lie, in this view, across a wide range of scientific and technological disciplines and sub-disciplines, ranging from the development of new chips to clinical trials for new drugs and pharmaceuticals. There is considerable ambiguity in this view whether the intended goal is the emergence of India as an equal player in the global economy or as a global knowledge outsourcing destination.

What in the short and medium term appears more likely, we contend, is the emergence of an `enclave' scientific and technological research sector that is an `outsourcing' appendage to a global system of knowledge production in specific fields, while catering to the security needs of a modern State. Such an `enclave' STI system is unlikely to provide an outlet for the vast creative potential that must undoubtedly exist in such a large nation.

At the same time the STI policies of the reform era have significantly begun undermining the role of scientific and technological research in producing public goods for the ``public good." If the pre-reform years were characterized by the weakness of the link, in practice, between poverty eradication and human development on the one hand and scientific and technological development on the other, the reform years have set the stage for the virtually full-scale decoupling of Indian STI from the task of reducing and erasing India's development deficit.

We turn now to a survey of some key features of the current state of STI in India to assess the validity and success of post-reform policy.

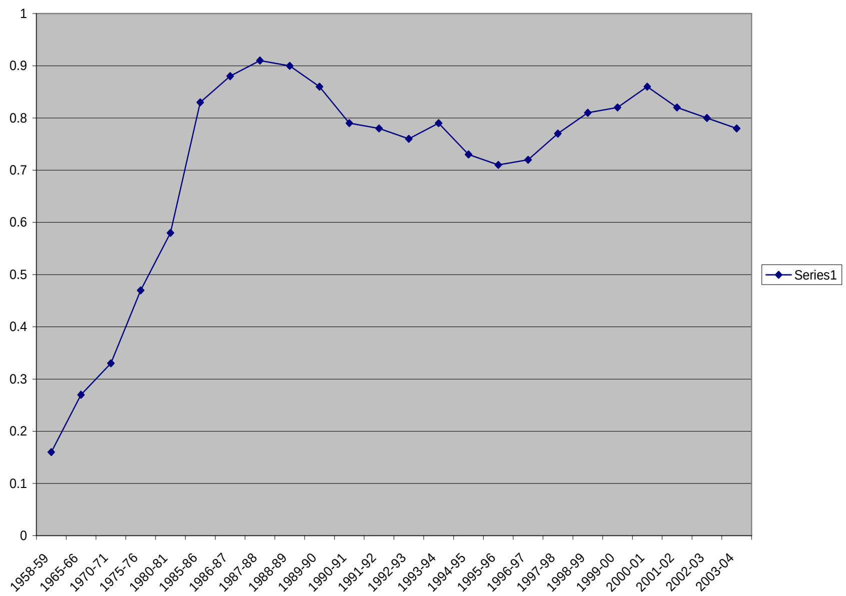
R&D EXPENDITURE

While R&D expenditure in the post-reform years continued to rise in general, it nevertheless did not keep pace with GDP growth. As shown in Chart 1, the rate of growth of R&D expenditure slowed down in the post-reform years as compared to the pre-reform years. The slower rate of growth of Gross Expenditure on R&D (GERD) is more tellingly reflected in the declining trend in R&D intensity (defined as GERD as a percentage of GDP) in these years, following more than three decades of an uninterrupted upward trend. The declining trend in R&D intensity was arrested only by 1999, though the subsequent rise, with some fluctuations, has not brought it back to the highest level of a little over 1% in 1987-88.

To put these figures in perspective, we note that whereas India had a research intensity of 0.78 in 2001, Brazil had 1.05 in 2000, China 1.09 in 2001 and Korea 2.96.[6] Korea's R&D intensity rose for instance from 0.77 in 1980 to 2.71 in 1995.[7] Among the developed countries in 2001 the highest figures were Sweden with 4.6, Japan with 3.09 and the United States with 2.8.[8]

6 Measures of progress of science in India: An analysis of the publications output in science and technology, NISTADS, 2006. Available on the website http://psa.gov.in
7 S. Mani, Government, Innovation and Technology Policy, Edward Elgar, Cheltenham, UK, 2002.
8 Measures, ibid.

Chart 1



The grouping of select countries (table 1 below) according to three R&D intensity levels, below 1%, 1-2% and greater than 2%, suggests that India's research intensity remains generally below the standards of the developed and the leading developing nations.[9]

Table 1

EXPENDITURE ON R&D AS PERCENTAGE OF GDP FOR SELECTED COUNTRIES, 2000 -02

		R&D/GDP			
0.0 - 1.0%		1.1-2.0%		above 2.0%	
Argentina	0.39	Australia	1.55	Austria	2.21
Cuba	0.62	Brazil	1.04	Denmark	2.51
Egypt	0.19	Canada	2.00	France	2.27
India	0.80	China	1.23	Germany	2.64
Nepal	0.67	Czech Repub.	1.30	Israel	5.11
Pakistan	0.27	Hungary	1.01	Japan	3.11
Sri Lanka*	0.20	Italy	1.11	Repub. of Korea	2.91
Thailand	0.24	Russian Federation	1.24	Singapore	2.20
Venezuela	0.38	Spain	1.04	Sweden	4.27
		U.K	1.88	USA	2.67

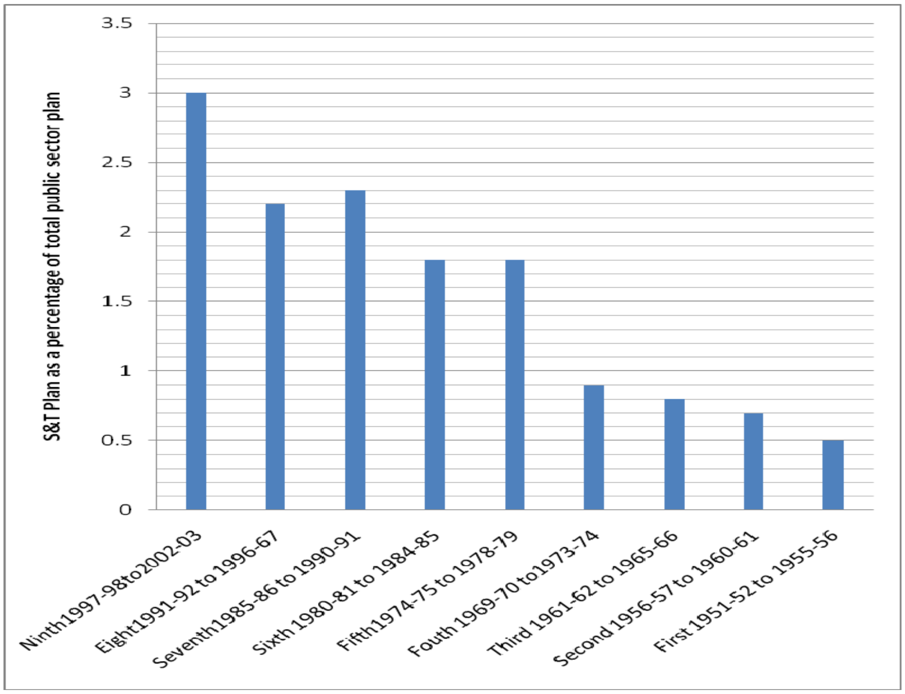
Source:-UNESCO Institute for Statistics (UIS) 2005, UNESCO.
World Development Indicators 2004/2005, The World Bank

Note : 1. China excludes Hong Kong
2. * 1996

9 Research and Development Statistics, 2004-2005, published by the NSTMIS, Dept. of Science and Technology, Govt. of India.

There was some reduction in plan expenditure for S&T as a whole in the Eighth Five-year Plan as compared to the Seventh Five-Year Plan. This followed the relatively slow rate of growth of the S&T Plan between the Fifth and Seventh Plan. Plan expenditure began to rise again subsequently in the Ninth Five-Year Plan (Chart 2).

Chart 2

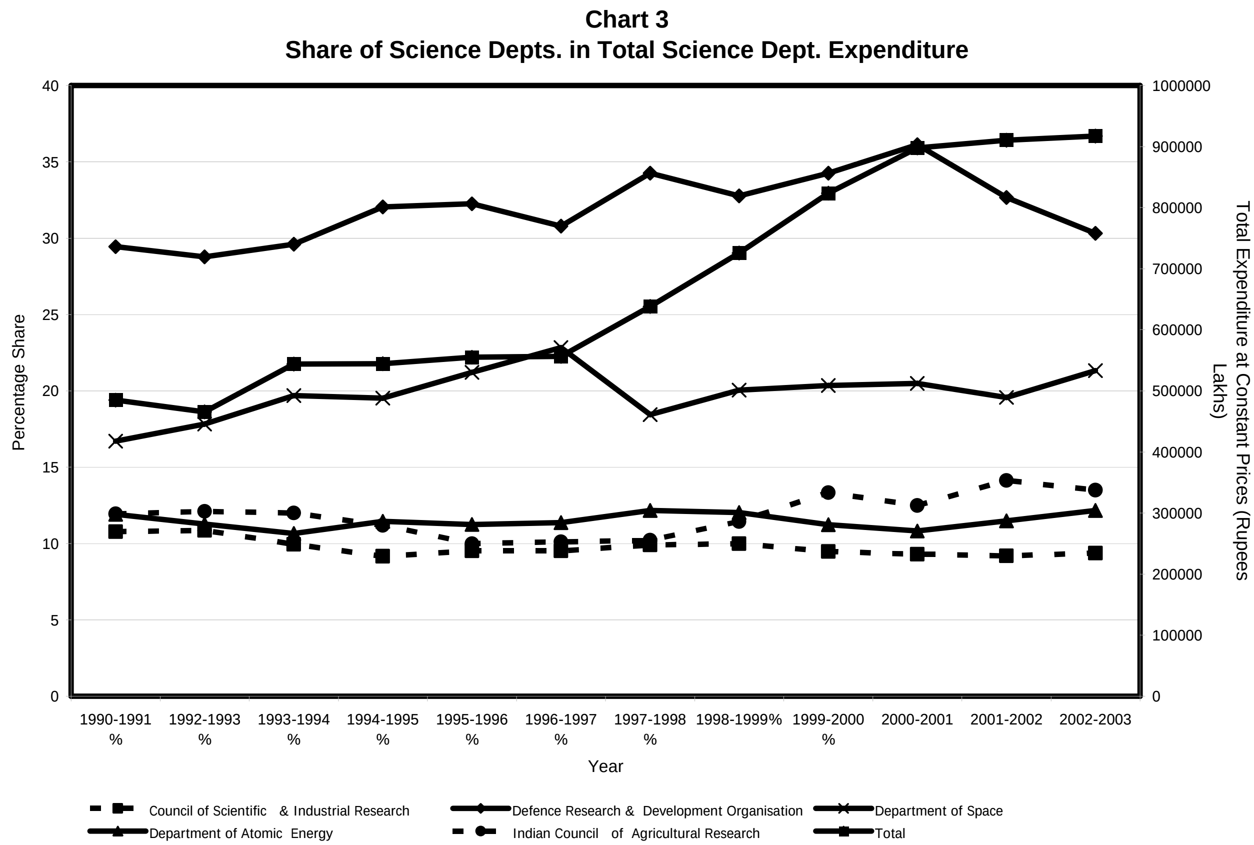


Significantly, in the post-reform era, there have been no major changes in the intra-sectoral distribution of Government expenditure in research. In the expenditure of the Govt. science depts., the major departments have more or less kept their share except for the Department of Space that has seen a rising trend. This is evident from fig. 3 below[10] (the trend for the total expenditure, at constant prices, of the government science departments is given alongside for comparison).

Data is available for other departments as well, which are however not included here since their contribution is of the order of less than 10%. This includes both the Dept. of Science and Technology, that gets roughly a 5% share and the Dept. of Biotechnology that gets between 1 and 2 %. Total Plan expenditure of the Government science departments has also been rising in real terms in the post-reform era.

Thus the pattern of S&T funding does not signal any serious effort at the re-ordering of priorities in the science sector in terms of the Government expenditure of the science departments.

10 Research and Development Statistics 2004-2005, op cit. Note that from 1995-96 the figures refer exclusively to Plan expenditure. This data is problematic. Thus the meaning of ``R&D'' expenditure varies somewhat between departments. Nevertheless we believe that this data is useful for the limited purpose for which it is used here.



Part of the reason lies undoubtedly in the special significance of the atomic energy, defense research and space sectors. In the first instance these sectors have a strategic significance. As the development of nuclear weapons and the ongoing efforts of the missile program have demonstrated, the Indian state is not likely to de-prioritize these sectors in the near future. Secondly, all three sectors have considerable political prestige attached to them and any attempt to downgrade these sectors would carry considerable political costs for any government that attempted any steps in this direction. However this does not of course preclude the re-ordering of priorities in these sectors as demonstrated by the new enthusiasm for projects that are also politically attractive such as the new series of lunar, inter-planetary and manned space flight projects that are currently on the agenda of the space program. Thirdly, any attempt to align the S&T policy in these sectors with the general program of opening up the economy had to clearly to await the easing of technology controls that had been imposed on these programs by international players. Till such time as this easing of controls occurred it was clearly premature to implement the new perspectives in these sectors. We may also add to these considerations the considerable political resistance to various measures to shift priorities in these sectors as demonstrated in the extended debate in the public and political sphere over the Indo-U.S. nuclear deal.

The effects of the policy shifts of the reform era are therefore not to be seen in these sectors but in other areas, particularly industrial research.

The share in total research expenditure by the sector in which it originates is shown in table 2.[11] While the share of industrial R&D in the total expenditure on R&D significantly rose in the period 1990-91 to 1995-96, from 13.8% to 21.7%, it has since stayed essentially at slightly lower levels between 18 to 20%. Notably the share of the higher education sector has remained fairly marginal in terms of R&D expenditure. We shall comment on this fact further later on. The contribution of the industrial sector is fairly low by international standards even among developing nations. China for instance spends as much as 64% of its expenditure in the industrial R&D sector.

Table 2

	Government	Industry	Higher Education
1970-71	89.55	10.45	
1975-76	88.13	11.87	
1980-81	84.13	15.87	
1985-86	87.82	12.18	
1990-91	86.16	13.84	
1995-96	78.26	21.74	
1998-99	75.79	21.17	3.04
1999-00	77.21	18.46	4.33
2000-01	77.94	18.05	4.02
2001-02	76.48	19.33	4.20
2002-03	75.56	20.27	4.17
2003-04	75.44	20.05	4.51
2004-05	73.92	19.81	4.88

The share of the private sector as the source of research expenditure in industrial R&D however shows a much more significant increase as is evident from the table 3 below.[12]

11 Sourced from Research and Development Statistics, 2004-2005 in S. Mani, ``Financing of industrial innovations in India: How effective are tax incentives for R&D"CDS Working Paper Series, No. 405. 2008.

12 Mani, op. cit.

Table 3: Growing privatization of industrial R&D in India, 1985-86 to 2002-03 (Rs in Millions at current prices)

	Government			Private Sector enterprises	Industrial R & D	Share of Private Sector In Total Industrial Development
	Public Sector Enterprises	Govt.Research Institutions	Total government			
1985-86	1986.18	1622.7	3608.88	2519.44	6128.32	41.11
1986-87	2356.99	1723.36	4080.35	2916.33	6996.68	41.68
1987-88	2884.66	1851.29	4735.95	3102.67	7838.62	39.58
1988-89	3421.24	2093.28	5514.52	4176.25	9690.77	43.10
1989-90	4129.01	2395.21	6524.22	4906.94	11430.16	42.92
1990-91	4145.33	2491.88	6637.21	5499.81	12137.02	45.31
1991-92	4843.88	2745.50	7589.38	6369.44	13958.82	45.63
1992-93	5139.50	2993.65	8133.15	8362.47	16495.62	50.70
1993-94	5428.11	NA	NA	9825.37		
1994-95	4146.09	3564.00	7710.09	13188.70	20898.79	63.11
1995-96	4275.76	4116.99	8392.75	16270.69	24663.44	65.97
1996-97	5360.52	4440.00	9800.52	23307.50	33108.02	70.40
1997-98	5392.40	5641.30	11033.70	24382.50	35416.20	68.85
1998-99	6738.70	7133.20	13871.90	21766.10	35638.00	61.08
1999-00	7576.30	7808.82	15385.12	21781.10	37166.22	58.60
2000-01	8428.80	8641.20	17070.00	24114.00	41184.00	58.55
2001-02	7673.70	8922.60	16596.30	27874.80	44471.10	62.68
2002-03	8089.50	9512.50	17602.00	30649.30	48251.30	63.52

Source: Department of Science and Technology (2006)

But this increase in private sector research expenditure remains restricted to industrial R&D that accounts for only about 20% of all expenditure.

HUMAN RESOURCES FOR S&T

No consideration of the development of S&T capabilities can be complete without consideration of the state of higher education (within of course the overall state of education) in the country.

The expenditure on higher education as a percentage of GDP has shown no increase post-1990. From 0.55% of GDP in 1989-90 it declined till 1997-98 to a low of 0.35% of GDP.[13] Subsequently it has shown some increase to reach 0.46% of GDP in 2000-01. By world standards, India's gross enrolment in higher education is far less than the norm[14]. At 7.2% in 1997, India's figure was well below the world average of 17.4%. It lagged behind the Asia/Ocenia average of 42.1% and was of course far behind the North American average of 80.1%.

The reform period has also been marked, as is well known, by a concerted effort for the withdrawal of the state from the higher education sector in general, with substantial increases in the number of private educational institutions in professional and general higher education. The increase in the number of such institutions has also been accompanied by steep increases in the fees charged by the new educational institutions as well as the older institutions.

13 J. B. Tilak, EPW,
14 Ravi Kumar and Vijendra Sharma, EPW,

Nevertheless the output of graduates in the sciences and technological disciplines has continued to rise steadily at the graduate level. However in the sciences in particular the output of post-graduates rose at a slower pace while the increase in the number of doctorates was even slower. Between 1979 and 1995 the annual number of doctorates in science rose by only approximately 40% (See Table 4).

Table 4

OUT-TURN OF S&T PERSONNEL FROM UNIVERSITIES BY FIELD OF SCIENCE AND LEVEL OF QUALIFICATION

(Number)

	Graduate			Post Graduate			Doctorates			Total		
	1979	1989	1995	1979	1989	1995	1979	1989	1995	1979	1989	1995
Science	99749	134366	139257	17638	24591	23807	2262	3044	3155	119649	162001	166219
										(70.6)	(69.8)	(70.5)
Engg. & Tech.	18364	28927	32250	3155	4560	3667	506	560	546	22025	34047	36463
										(13)	(14.7)	(15.4)
Medicine	15090	17968	19613	3485*	5945*	4634 *	-	-	-	18575	23913	24247
										(11)	(10.3)	(10.3)
Agriculture & Vet. Science	6280	8301	5752	2384	2876	2284	480	792	827	9144	11969	8863
										(5.4)	(5.2)	(3.8)
Total	139483	189562	196872	26662	37972	34392	3248	4396	4528	169393	231930	235792
	(82.3)	(81.7)	(83.5)	(15.7)	(16.4)	(14.6)	(2.0)	(1.9)	(1.9)	(100.0)	(100.0)	(100.0)

Note: *Includes Doctorates in Medical Sciences.

These numbers must also be seen in the perspective of well known criticisms regarding the quality of scientific manpower produced by the Indian higher education system, traceable at least in part to the poor quality of educational infrastructure including laboratories and library facilities.[15]

A number of factors seemed to have contributed by the year 2003-2004 to a fall in the availability of suitable candidates for employment in the scientific research sector. These certainly include the rise of the IT/ITES sector as a significant employer of graduates/post-graduates and the relative unattractiveness of research as a career in an era of relatively high wages in a few emerging sectors, This lack was particularly felt in the scientific agencies of the Central government. From 2004 both the office of the Principal Scientific Advisor to the Govt. of India and the office of the Scientific Advisory Committee to the Prime Minister have been preoccupied by the shortage of qualified entrants to the scientific profession.[16]

15 A welcome countervailing trend is represented by the efforts of the University Grants Commission to provide access through the Inflibnet network to a wide range of scientific and scholarly literature. Other similar on-line consortium agreements for access to literature (that represents a critical component of research expenditure) have also become more widespread.

16 Report of Committee constituted by the SAC-C to examine and recommend New Science Education Initiatives from 10 + 2 onwards" , available on the website of the Principal Scientific Advisor to the Govt. of India at http://psa.gov.in and related background papers available there. Peculiarly though much of the report is devoted to solving the human resources constraint by improving science education rather than consider deeper socio-economic constraints that are widely acknowledged, albeit informally, in the scientific community.

Some effort has been made to make academic careers more remunerative with the increases in pay offered by the Fifth and Sixth Pay Commissions. However these increases still keep academic salaries in government and government-aided institutions well below private sector salaries, especially when set against the longer period of training required before commencing an academic career.

Despite the scientific community raising the alarm as early as 2003-2004, it is only some years later that a significant program of expanding the Central Government sector in higher education has been announced. This includes new Indian Institutes of Technology in some states, new institutes (patterned after the IITs) that will teach basic sciences and a whole set of new Central Universities. While some of these have been announced for electoral or other short-term political reasons, nevertheless the planned expenditure on these institutions constitutes the first serious expansion of the higher education system at the level of ``centers of excellence" after a long period of relative stagnation. We shall return to the significance of this expansion in a later section.

Nevertheless the bulk of the higher education system accounts for a minor fraction of the total R&D expenditure. Of this fraction a significant amount is spent on institutions such as the IITs, the Indian Institute of Science and a few other institutions. It is unlikely that this picture is to change in the immediate future. This was explicitly demonstrated in two successive budgets of the UPA government when, despite the plea of the scientific community for greater all-round increases in expenditure, allocations were made only for the development of select institutions in the country. Going by current trends, the new institutions are likely to exacerbate this skewed character of R&D expenditure in the higher education sector.

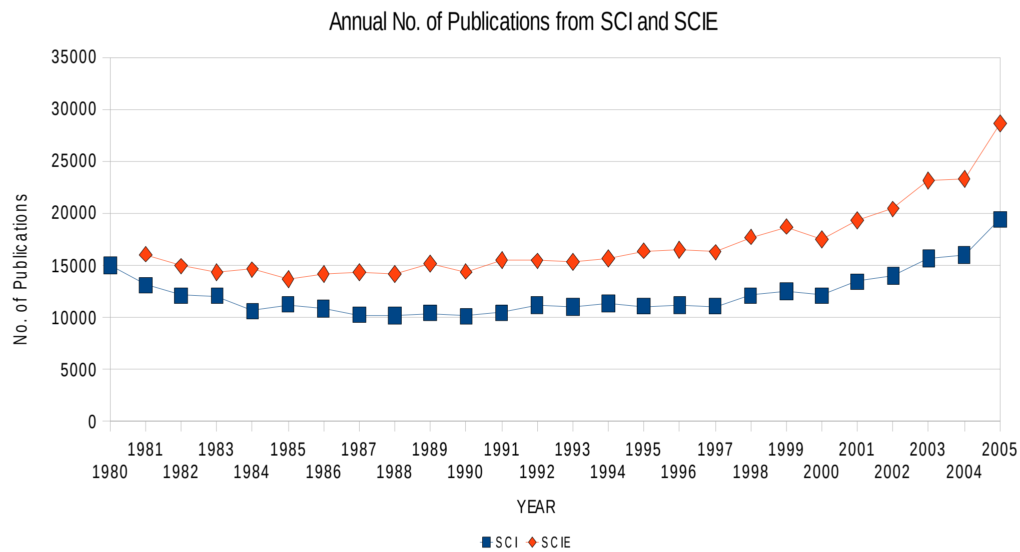
S&T OUTPUT IN PUBLICATIONS

The most obvious form of the output in basic science research is the research publication. In the last several decades, bibliometric data, or more precisely scientiometric data, has emerged as one of the significant quantitative tools for the analysis of scientific productivity. The key data include the total volume of publications from different regions, the number of citations that published papers from a region obtain and the impact factor (measured by different methods) of the journals in which papers from any region are published. Despite its many limitations, bibliometric data remains one of the few general measures of scientific productivity that covers basic and applied sciences and overcomes the skewed character or subjective limitations of measures such as the number of international awards (particularly the Nobel Prize) that the country's scientists get, considerations of name recognition of Indian scientists, etc.

The data at a global level reflects the overwhelming dominance by the developed world of the knowledge domain. Developing countries contribute only 12.73% of world publication output and their publications attract only 5.63% of all citations. The data on scientific publications from India, both in itself and in comparison with the data for other countries indicates a more complex picture in respect of the strengths and weaknesses of scientific research in India. The picture is further complicated by the partly divergent findings from data emerging from two different databases.

Scientific publications from India registered an absolute decline in the annual production of papers beginning in 1980 (with 14, 983 publications for that year) according to the Science Citation Index (SCI) database (Chart 4).[17] This number reached a low of 10,978 in 1993 and then gradually increased to reach 12, 127 in the year 2000, thus not having recovered the ground lost even over a span of two decades. In the same period, Chinese output rose by a factor of 23, partly of course as a consequence of starting with a low base. South Korea began the same period with an insignificant 175 publications to virtually level with India by 2000. Brazil also registered steady growth during this period (Table 5).

Chart 4



However a study conducted by the office of the Principal Scientific Advisor to the Prime Minister used also data from SCIE – an expanded database – that provided a more comprehensive coverage of publications from India.[18] Thus it is argued in the study, that the SCIE database presents a more accurate picture of scientific publications from India The data on Indian scientific publications from both the SCI and SCIE databases are presented below if fig. In this respect scientific publications from India show a less distinct decline in growth in the 80s followed by an earlier and slightly more rapid recovery.

17 S. Arunachalam, Current Science, Vol. 83, No.2, 25 July 2002, p. 107.
18 Measures, op cit.

Table 5

Table 2 Number of papers published by five selected countries from SCI data

Year	India	China	Israel	S. Korea	Brazil
2000	12127	22061	9292	12013	9565
1999	12521	17138	9241	10918	9083
1998	12128	14610	9544	9444	7917
1997	11067	12630	8938	7728	6954
1996	11177	10152	8338	6227	5895
1995	11084	9713	8141	5125	5289
1994	11319	8226	7787	3684	4381
1993	10978	8087	7563	4318	4043
1992	11160	7630	6755	2248	3946
1991	10468	6630	6206	1818	3438
1990	10103	6509	6211	1448	2973
1989	10426	5491	6262	1332	2697
1988	10208	5312	6861	1075	2492
1987	10239	4048	6948	944	2859
1986	10854	3678	6729	773	2951
1985	11222	3238	6792	664	2511
1984	10600	2537	5570	440	1915
1983	12059	2974	6236	442	2248
1982	12124	2592	6058	321	2306
1981	13119	1544	5560	254	2374
1980	14983	924	5733	175	2215

Table 6 shows the growth rates of publications in different periods based on various databases.

Table 6

Period	Cumulative Publications Count				% Growth Rate			
	SCIE	SCI	SCOPUS	PASCAL	SCIE	SCI	SCOPUS	PASCAL
1981-85	73590	59124						
1986-90	72247	51830 -			-1.82	-12.33		
1991-95	78343	55009 +			8.44	6.13		
1996-00	86722	59020	105284	45710	10.69	7.29		
2001-05	114818	78601	139871	52183	32.4	33.17	32.85	14.16

It is clear from both databases that the decade of the 80s was one of negative growth in the number of publications, though the SCIE database shows a slowdown that was substantially less. However, roughly 15,000 to 20,000 publications were being missed every five years between the SCI and SCIE databases in the 80s and early 90s. Taking the data from both databases into account this suggests a dual phenomenon that ran its course through the 80s and well into the 90s. There was both a marginalization of Indian scientific publications on the world scene as well as an absolute decline, at least in the 80s, and a slow recovery in the number of publications through much of the 1990s. There appears to have been some acceleration in the publication rate subsequently particularly after 2000. To strengthen this reading would require a more detailed examination of the journals that are missed by the SCI database and further enquiry into the quality and status of these journals.

What is unambiguously clear from other data is that India's contribution in world scientific activity remains quite small. India's share to the global publication volume was 1.68% in 1993 according to the SCI database, rising marginally to 1.77% in 2003. According to the SCIE database, this share was higher, rising from 2.03% in 1993 to 2.08% in 2003. However in the same period other developing nations such as China and Brazil and countries such as S. Korea have also had a faster rising share of global publications as noted above.

The majority of publications continue to originate in the university and higher education sector. Publications from this sector contributed around 55% of all publications from India in the SCIE database.

PATENTING ACTIVITY IN INDIA

Following India's accession to the WTO and subsequently to virtually the full scope of the international IPR regime, the scientific leadership, the policy establishment and the political leadership have thrown their weight behind the significance of patents as indicators of the state of health of Indian science and technology. It is useful therefore to examine some of the data on patenting activity in India and from India.

Patenting activity in India is still dominated by applicants of foreign origin. The share of patents granted in India to Indians has risen over the years. However more than half of these patents is still granted to applicants of foreign origin as seen from the data in Table 7[19].

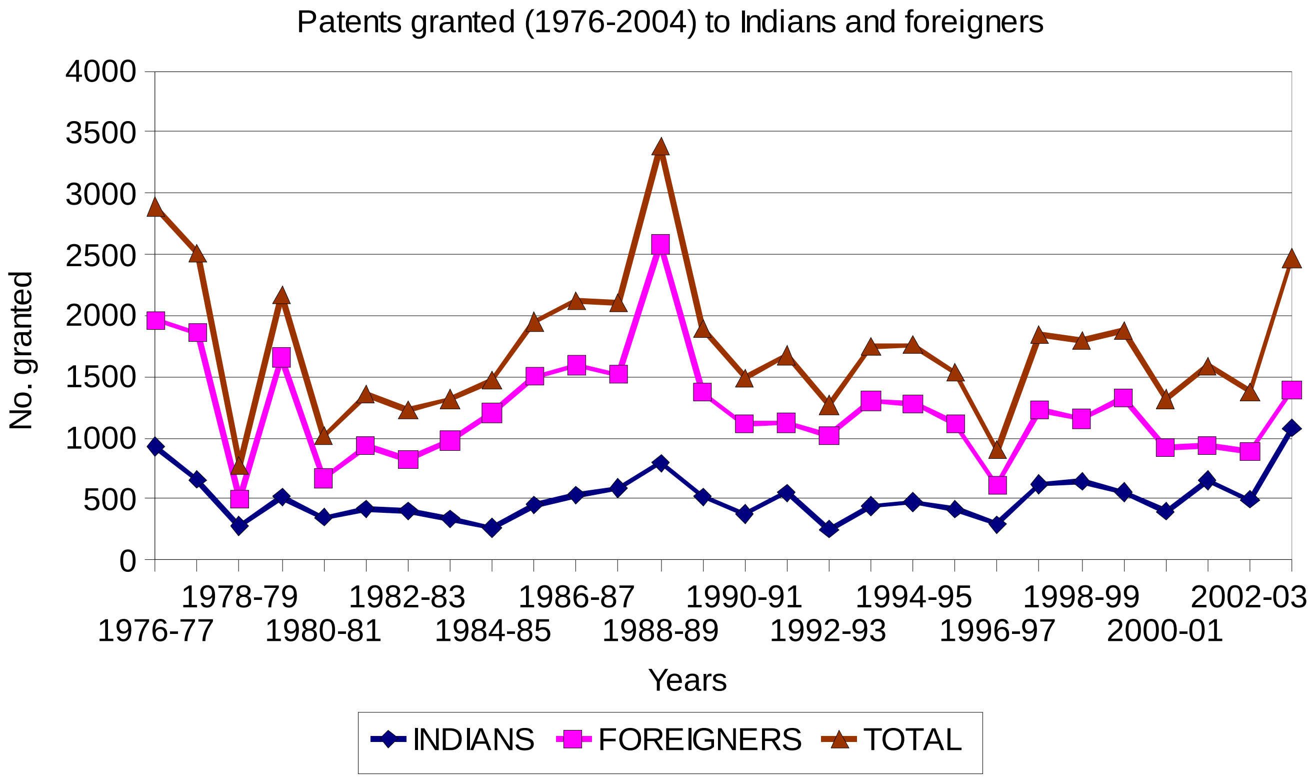
19 Data taken from Table 32 of Research and Development Statistics, 2004-05, op.cit.

Table 7

No. Of Patents Granted TO

YEAR	INDIANS	FOREIGNERS
1976-77	928	1964
1977-78	657	1857
1978-79	281	499
1979-80	516	1657
1980-81	349	670
1981-82	421	936
1982-83	405	822
1983-84	340	980
1984-85	263	1206
1985-86	451	1500
1986-87	532	1594
1987-88	588	1516
1988-89	795	2585
1989-90	519	1371
1990-91	379	1112
1991-92	551	1125
1992-93	251	1021
1993-94	442	1304
1994-95	476	1283
1995-96	415	1118
1996-97	293	614
1997-98	619	1225
1998-99	645	1155
1999-00	557	1324
2000-01	399	919
2001-02	654	937
2002-03	494	885
2003-04	1078	1391

Chart 5



It also shows that patenting activity in terms of total number of patents granted have not varied greatly over the last several years. This fact, despite the major changes that have taken place in the patenting regime over this period, suggests that the new patent regimes have not really taken hold either in terms of encouraging foreign entities to apply for Indian patents. At the same time there has not also been any considerable increase in the number of patents granted.

However the number of patent filings has increased substantially. From 3104 in 1976-77 and 3869 in 1993-94 it has jumped to reach 12813 in 2003-04. The gap between the numbers granted and applications made is explained by the number of patents carried over from previous years that in 2002-03 was 44,281 (Chart 5). In the number of patents filed the domination of non-Indian applicants is even more significant as seen in the table 8 below.[20]

20 Research and Development Statistics, 2005, op.cit. This actually understates the extent of patenting activity in India from foreign sources as it does not include patent applications through the Patent Cooperation Treaty route as well as the category of ``Mailbox" applications.

Table 8

Number of Patent Applications in India

Name	2002-03	2003-04
U.S.A.	2416	3128
Germany	857	939
Japan	731	484
France	299	436
U.K.	391	418
Switzerland	418	341
Netherlands	391	264
Italy	118	167
Russia	11	20
Other	3141	3198
Total	8773	9395
India	2693	3218
Total	11466	12613

Patenting activity was considerably skewed with 20 organizations accounting for approximately 60% of patents.[21] The bulk of the patents were filed by Industry and research organizations. Universities accounted for only roughly 3.5% of these patents. We shall comment on this later. 55% of the patents granted in the Indian Patent office to Indian organizations were in the drugs and pharmaceuticals and chemicals sector.

In fact as noted by Mani,[22] India's system of innovation may be thought of as dominated by the sectoral system of innovation of the pharmaceutical industry. In terms of R&D investment in industry in fact the pharmaceutical industry is closely followed by the automobile industry.

The stagnation of domestic patenting activity suggests that spillover effects from inward FDI activity in India are minimal, at least according one significant indicator of domestic innovative activity. In the context of inward FDI, the literature recognizes that the innovative activity in the host country may benefit in several different ways. Among these are host country firms learning by reverse engineering and local firms acquiring knowledge capacities through the movement of skilled workers from foreign-owned firms to local enterprises. A third category of spillover refers to the demonstration effect of FDI on innovation in the host country, whereby local firms are encouraged in their innovative capabilities, especially since FDI provides knowledge of products and processes that have been tested in other markets. Local firms may also undertake greater innovative activity for strategic strength in the face of the entry of new players. The absence of any significant increase in the annual number of patents granted, especially over a period that covers both the pre-reform and the reform era suggests that FDI has at least not increased patenting activity by domestic entities.[23]

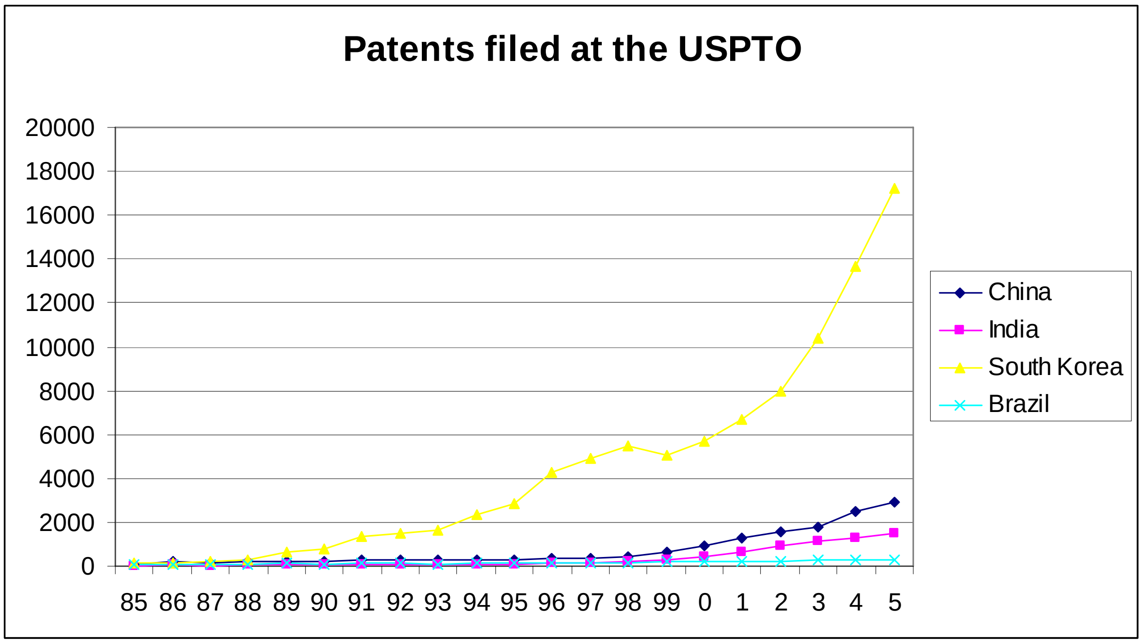
21 S. Bhattacharya, Current Science (2004), Vol. 92, No.10, p. 1336.

22 S. Mani, op. Cit.

23 The literature on China suggests in contrast that the jump in domestic patenting activity can be regarded as a positive spillover from inward FDI, though it is difficult to separate whether it is

One of the other key indicators of a country's footprint in the global knowledge industry is the number of patent filings in the United States Patent and Trademarks Office.[24] The number of patent applications filed by India has been increasing noticeably since 1999. It is interesting to compare these with the numbers filed by China, Brazil, and South Korea. The rapidly increasing gap between Brazil, China and India on the one hand and South Korea on the other is clear. China had roughly twice the number of patent filings as India while Brazil has fallen considerably both these countries. The contrast with Korea clearly underscores the relatively low position of India in the world knowledge economy (Chart 6).

Chart 6



due to the strategic behavior of domestic firms or genuine `knowledge' spillover. See in this regard, Hu and Jefferson, China's patent explosion.

24 From Appendix Tables 6-31 and 6-32, Science and Engineering Indicators, 2008. Available online at http://www.nsf.gov/statistics/seind06/c6/c6s7.htm

Country/Year	China	India	South Korea	Brazil	South Africa	Japan
1985	80	25	129	78	227	21,431
1986	178	36	162	68	204	22,895
1987	165	26	235	62	239	24,516
1988	208	41	295	71	192	28,357
1989	220	50	607	111	215	31,791
1990	197	58	775	88	185	34,113
1991	258	51	1,321	124	186	36,846
1992	279	64	1,471	112	207	38,633
1993	290	54	1,624	105	246	34,816
1994	319	70	2,354	156	238	37,768
1995	307	91	2,820	115	187	39,872

Country/Year	China	India	South Korea	Brazil	South Africa	Japan
1996	364	115	4,248	145	189	39,510
1997	324	137	4,920	134	174	41,767
1998	455	180	5,452	165	211	45,260
1999	660	271	5,033	186	179	47,821
2000	942	438	5,705	220	209	52,891
2001	1,252	643	6,719	219	231	61,238
2002	1,569	919	7,937	243	241	58,739
2003	1,763	1,164	10,411	259	224	60,350
2004	2,470	1,303	13,646	287	246	64,812
2005	2,943	1,463	17,217	295	197	71,994

Among the patents granted at the USPTO to applications from India between 1990-2002 the bulk were obtained by government research institutions of which the maximum by far was the CSIR.[25] Eight Indian organizations accounted for approximately 80% of the patents granted at the USPTO. Of the total of 1051 patents granted in this period, 278 were in pharmaceuticals and 219 in the chemicals sector. Miscellanous and biotechnology followed with 65 and 53 each. This illustrates again the preponderance of the pharmaceuticals and chemicals sector which belongs to an area of traditional strength.

HIGH-TECH EXPORTS

The relative position of India in the global knowledge economy is clearly revealed in the data on hi-tech manufacturing and exports from the National Science Foundation's Science and Engineering Indicators 2008 study. It is clear from the data that in the field of high-technology exports world-wide India has a minor role to play, dominated mostly by again pharmaceuticals and chemicals.[26] India's only strength in hi-technology is its software exports. Even here it may be remarked that both in software patents as well as software copyrights India's contribution is very minor.

FDI IN THE R&D SECTOR

A relatively new phenomenon, most significant following the opening up of the economy has been the setting up of offshore R&D centers in India by entities from other countries. This sector has been growing steadily. While the exact dimensions of this sector need to be mapped out a preliminary study has been produced by TIFAC.[27] By 2003, the study estimated the number of scientists working in offshored R&D institutions at 23,000. Estimating the remuneration of comparable scientists in the U.S. At $100,000 per annum this puts the annual value of services in this sector to be roughly $2.3 billion (software exports in 2003-2004 were worth $12.5 billion). The R&D investment planned was roughly Rs. 5099 crores. The bulk of these centers were from the US, accounting for 53 out of 100 companies studied. The majority of these companies operated without any local partnership and again more than 50% of them performed only in-house R&D for the home companies.

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25 S. Bhattacharya, et. al. Indian Patenting Activity in Domestic and International Patent System, NISTADS, 2005. Available at http://psa.gov.in

26 For an earlier analysis see C. P. Chandrasekhar and Jayati Ghosh, Knowledge and the Asian Challenge.

27 FDI in R&D: Study for the Pattern 1998-2003, TIFAC publication,

A study[28] of FDI in R&D in China and India examined three hypotheses in this regard. Firstly is the science base and availability of human resources the key factor thus attracting knowledge intensive MNCs to these countries. Secondly, is the knowledge intensity of these offshored R&D in China and India low compared to their activity in other regions. Thirdly does this work erode the science base of the Indian and Chinese economies in the short-term. The study using USPTO and publication data concluded positively with regard to all three questions.

China currently has over 750 MNC R&D centers. A study[29] of the impact of these centers concluded that these centers behave more as enclaves and have little interaction with local companies. The study notes that few apply for patents in China and their output is often for incorporation in other materials and products. While they have ostensibly much contact with local educational and research institutions their contacts are not very deep.

In other countries like Brazil the MNC R&D centers find it useful that the products of the educational system are more attuned to their needs than that of the local companies. Thus they have more contacts with the local universities than local firms. The Korean experience suggests that positive spillovers from offshored R&D effects require a dynamic innovation base that is able to absorb these effects. [30]

NEW POLICY INITIATIVES IN S&T

The Indo-US nuclear deal marks the threshold of a new policy thrust in the STI arena that pushes ahead further along the same path that we have outlined in the reform era. We have already remarked on the significance of the deal as related to the opening up of the nuclear energy sector after the security interests of the Indian State had been reasonably (in their view!) safeguarded. However it is interesting to note that several other initiatives in science policy weere closely tied to these developments. These developments include the passage of domestic legislation that was closely influenced by the negotiations with the United States in the period that the deal was in the making.

These include the Knowledge Initiative In Agriculture, a program to promote collaboration in agriculture, billed by the Indian Government as the second Green Revolution. Its hallmark is that it deals with the transfer of proprietary knowledge in agriculture, including GM technology, mostly through MNCs and not through public institutions. The contrasts in this regard with the original Green Revolution are striking.

The second initiative is the passage of a new act on the patenting of publicly funded research that is patterned after the Bayh-Dole Act of the United States. A brief comment on this bill, presented as a note for discussions among parliamentarians is presented as an Appendix.The

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28 S. Athreye and M. Prevezer, R&D offshoring and domestic science base in India and China, CGR Working Paper Series, No. 26, Queen Mary College, London.

29 Xue Lan and Zheng Liang, Multinational R&D in China: Myths and Realities, Paper presented at the OECD-MOST workshop, Beijing, Oct. 2006.

30 N. Mrinalini and S. Wakdikar, Foreign R&D Centers in India: Is there any Impact? Current Science, Vo. 94, No. 4, 25 February, 2008.

language and content of this note I believe sums up the main points made in this paper in shorter, crisper form as well underlining the motivations for writing it.

CONCLUSION

It would be clear from the foregoing analysis that the Indian STI system still substantially depends on the capacities built in an earlier era. It is clear that the original drive for scientific and technological development was powerful enough to have delivered in many ways even when the policy vision that underlay it has been substantially downgraded.

Unfortunately this is not sufficient at this juncture. The twin challenge of inclusive development and sustainable development require greater technological inputs and not less. It is at this moment that the Indian state has pursued its neo-liberal agenda in the science, technology and innovation arena with renewed vigour.

Many nations that have successfully weathered economic downturns have done so by turning to greater innovation and technological upgrading. The current economic crisis and its effects suggests that India needs to do the same though the manner of providing a boost to science and technology cannot be undertaken in the same manner as was done earlier by economies such as Korea or Japan. The current dispensation in New Delhi does not appear to be prepared to deviate from the path that it has followed so far. The solution clearly lies as much in the realm of politics as policy.

The future of STI in India will depend on how the political challenge posed by the neo-liberal turn is met at the current juncture.

APPENDIX ON THE INDIAN VERSION OF THE BAYH-DOLE ACT:

The bill titled ``The Protection and Utilization of Publicly Funded Intellectual Property Bill, 2008" is a legislation that has serious negative implications for the development of S&T in the country and the development of S&T to address India's national and social needs and aspirations. We outline below our views on this proposed legislation.

1. Bayh Dole Act and the Similarities to the Current Legislation

1.1. It has been widely noted in the media that this legislation has been patterned after similar legislation enacted elsewhere in the world, particularly the Bayh-Dole Act of the United States. However, the conditions under which research is conducted in India, compared to the advanced industrial nations, is quite different and copying of similar legislation can be inimical to the growth of scientific research in the country. Even in the United States it has been widely argued by leading experts and authors that the benefits of the Bayh-Dole Act are completely exaggerated (See attached note by Bhaven Sampat et. al.)We shall refer to these experiences in our comments below.

1.2. The basis of seeking intellectual property rights for publicly funded research is explained in the Objects and Reasons of the proposed legislation. The Government seems to believe that more protection of intellectual property is a desired goal and has put in place what it believes is an instrument for this. However, there is no common strategy regarding how a country should look at Intellectual property.

1.3. The desirable form of IPR protection is very much a function of development. Currently, the developed economies feel they should protect their IPR and restrict their dissemination. But these same countries have historically had much more lax IPR regimes that have allowed imitation to promote more rapid industrialisation. So there is a strong case for providing less IPR protection in the development phase, especially in those areas where domestic innovation is less advanced.

1.4. There is no clear correlation between high IPR protection and innovation, and much historical evidence to the contrary. A significant number of studies have shown that patents are important primarily in chemicals, chemical materials and pharmaceuticals, where patents can protect specific molecules or well defined but small slices of technology. In other areas, patents tend to be relatively less important in promoting innovation.

1.5. This means that India should first identify what are its national interests and then calibrate the IPR protection accordingly. For example, in pharmaceuticals, the current national interest lies clearly in restricting patents. This is also why the Indian Parliament has taken advantage of the flexibility of TRIPs to raise the bar of what is patentable. Indeed, some of these measures are now being copied by other countries including the US.

1.6. In the US before Bayh Dole Act was introduced, all publicly funded research was publicly owned. The Bayh Dole Act reversed this and made the institutions and researchers the owners of the IP. In India, there was no similar bar and in fact publicly funded research was encouraged to provide IP protection if the institution and researchers so desired. Therefore, the proposed legislation does not add anything of value to the current practice except mindlessly forcing IP protection on *all* publicly funded research.

1.7. Instead of blindly copying legislation from advanced countries, whose objectives are different, we need to provide alternatives that are appropriate for us and to our national needs.

2. Specific Problems with the Clauses making it Unworkable

The current bill mandates the seeking of intellectual property rights by the researchers and academic and research institutions whose work is supported by Government funds. Further the institution is obliged to seek intellectual property rights for research produced by its faculty, scientists, etc. in all countries that he chooses to. In countries where they do not seek patents or copyrights for his work, the intellectual property rights automatically revert to the Government. To enforce this, every institution receiving Govt. research grants has to set up a committee that must assess every potential piece of research conducted in that institution for its IPR potential, conduct market research to market such intellectual property, license the intellectual property and manage the revenues obtained from such licensing.

2.1. Firstly, these requirements are unworkable and cannot be implemented without putting an enormous strain on our research and teaching institutions that are already severely strained in many ways. The intellectual property committee proposed has so many duties that every research and teaching institution, such as the average Indian university, will be required to set up a sizable bureaucracy and establishment to undertake the activities of this committee. Few institutions in India have the resources to make such a committee function meaningfully. Setting up such committees and burdening them with such heavy responsibilities without the required resources will simply create yet another layer of bureaucracy and stifle all research. Nor does the bill envisage any mechanism for the government to support and assist such IPR committees, through the provision of funds.

2.2. Even in the United States, very few institutions have the capability to monitor and license their intellectual property. In fact, studies show that the bulk of U.S. universities spend more on establishing and maintaining their intellectual property rights than what they earn from licensing such rights. Filing for intellectual property rights amounts to no more than a matter of prestige without any financial gains for these institutions (See note by Bhaven Sampat et. al).

2.3. Secondly, the conditions of the bill amount to the fact that no research work can be sent for publication until and unless the IPR committee has in fact first decided on the IPR potential of every such piece of research. It is obvious that this will lead to severe delays in publishing even routine research work. The bill prescribes stiff penalties (in clauses 20, 21, 22) for the non-performance of the prescribed IPR duties by researchers and their institutions. Clause 19 provides little protection against the threat of penalties except in vague generalities. The threat of such penalties, together with provisions for the duties of the proposed committee, will effectively delay considerably the publication of research.

2.4. Thirdly, such mechanisms to determine intellectual property potential before publication will eventually kill creativity in the vital area of basic research. In the case of advanced, frontier research it is often unclear what potential benefits and commercial applications may result in the future. If such decisions have to be made for every piece of research, the majority of researchers may in the end opt for safe, routine research that passes scrutiny easily, rather than arguing over the relevance and significance of path-breaking research.

2.5. Fourthly, it is not clear who or which body has the final say in whether a particular result from government-funded research constitutes intellectual property with commercial potential or not. This is a source of conflict, delays and confusion. It is also clear that the bill proceeds on the assumption that it will be easy to identify all intellectual property with commercial potential arising out of all research. As the history of science shows this is at best a very dubious proposition. Nor does the bill have any provision for the resolution in a negotiated manner of any disputes that may arise between the researcher, the institution and the government.

3. Public Interest in Scientific Research Completely Overlooked

The overall thrust and contents of the bill raise other serious issues that need consideration.

3.1. The current bill has no clear mechanisms for the protection of the public interest especially for research, development and innovation in critical social sectors. The pursuit of intellectual property rights for the highest profit from its marketing has been given the first priority. Even if a researcher or an institution desires to put its results in the public domain so that it benefits society at large, the bill empowers the government to seize such intellectual property and commercialize it by licensing it to profit-centered enterprises whether they are Indian or multinationals. No socially conscious or well-meaning researcher can produce a vaccine, a critical drug, a useful renewable energy technology or a critical advance in clean, emission-free technology without the danger of its being seized by the government for licensing to Indian or multinational corporates.

3.2. From the experience of the United States it is clear that the opposite can also happen with equally negative consequences for the public good. Some universities in the United States have used their ability to claim intellectual property to actually block or seriously hamper further development of important scientific research for the public good. One such case is stem cell research by the University of Wisconsin. Apart from charging excessive royalties for licensing its work, this university also seeks to claim royalties on all the successive developments that follow from the use of its work (See attached note by Bhaven Sampat, et. al.)

3.3. In the Indian context, it is conceivable that multinationals may set up Indian subsidiaries that could use government funds for research and then patent their results to make super-profits on a worldwide basis. The restriction that some production must take place in India is a minor and essentially irrelevant restriction.

3.4. The claim in the statement of objectives that this bill will promote innovation in small and medium enterprises (SMEs) is not tenable. It is well-known that the whole IPR mechanism precisely is against the interests of the SMEs, since the costs of patenting and maintaining patents are prohibitive for such enterprises without active intervention by the State. It is likely that innovations from SMEs will be sold by them to larger corporates who will then exploit their hold on this intellectual property to boost their profits without concern for the public good.

4. Self-Reliance as a Driver of Innovation in India

4.1. India today definitely needs to develop further and strengthen a culture of innovation. But the entire experience of science in India and the experience of the public sector, especially the Navaratnas, show that the ideal of self-reliance can be one of the most powerful motivators for innovation. The bill itself exempts the atomic energy sector from its scope. If innovation will nevertheless advance in that sector without the carrot of intellectual property rights, then it is not clear why the same cannot be true of many socially important sectors and sectors that are critical from security and other perspectives.

4.2. The bill is a legislation that is uncritically based on the argument that intellectual property rights are the sole driver of innovation and scientific advance. As many leading experts testify (see Bhaven Sampat et. al) this is entirely debatable. Currently patents have been increasingly recognized as in fact a drag on innovation and scientific and technological advance, allowing large monopolies to extract rents by their possession of intellectual property. Innovation and scientific advance still takes place in the hands of large numbers of individuals and institutions, both big and small, but it is the mechanism of intellectual property rights that allows the fruits of their labour to be bought by large corporates that seek increasing profits from their ownership of knowledge that they did very little to create.

4.3. It is a truism that the pursuit of profits through the ownership of intellectual property rights and purely market-oriented research completely distorts the character of scientific research. Drug companies will do nothing for diseases that kill millions while pursuing research directed at products like Viagra or other lifestyle drugs. Agriculture research that is of vital interest to developing nations languishes while large multinationals push products that benefit solely their interests. Research into large-scale renewable energy to combat climate change still languishes as the big multinational corporations seek ways to maintain their monopolies over existing forms of energy sources and energy production.

5. Conclusions

An emerging scientific power like India needs to ensure that its increasing public investment in science is directed at public, social and national needs rather than selling its scientific and innovation talents to the highest bidder. The proposed legislation is unfortunately a step in the reverse direction. Also, in the name of protecting publicly funded IP, it will make the process of research even more bureaucratic ridden and only help in stifling research rather than promote creativity and innovation.