CREST OMC Working Group

Internationalisation of R&D – Facing the Challenge of Globalisation: Approaches to a Proactive International Policy in S&T

Country Report India: An Analysis of EU-Indian Cooperation in S&T

Prepared on behalf of the CREST OMC Working Group by
Jan Peter Wogart

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Preface

This report gives an overview of the existing cooperation in science and technology with India at EU, Member States and Associated Country level. It is one of three country reports (Russia, India and Brazil) prepared in the frame of the work of the CREST OMC Working Group on '*Internationalisation of R&D - Facing the Challenge of Globalisation: Approaches to a Proactive International Policy in S&T*'.

The following 20 Member States of the European Union and countries associated to the EU Framework Programme for Research, Technological Development and Demonstration Activities participated in the OMC Working Group in 2008: Austria, Czech Republic, Cyprus, France, Germany, Greece, Iceland, Ireland, Italy, Lithuania, The Netherlands, Norway, Poland, Portugal, Romania, Spain, Sweden, Switzerland, Turkey and the United Kingdom. Eight meetings of the OMC Working Group were held between January and November 2008.

The chair of the OMC Working Group was Jörn Sonnenburg (International Bureau of the German Federal Ministry of Education and Research at the German AeroSpace Centre); the rapporteur was Marion Steinberger (International Bureau).

The OMC Working Group was supported by Ales Gnamus from the Institute for Prospective Technological Studies at the Joint Research Centre of the European Commission (JRC-IPTS) and three external experts: Manfred Spiesberger, Jan Peter Wogart and José Luis Briansó Penalva.

Continuous assistance was provided by Sigi Gruber and Heiko Prange-Gstöhl from the European Commission, Directorate D, unit D2.

This report was prepared by Peter Wogart on behalf of the OMC Working Group. The report sums up the results of the independent individual desk research and the analytical and empirical work (analysis of responses to several short questionnaires that were sent to the members of the OMC Working Group or to national CREST delegates), mutual learning exercises and thematic discussions of the OMC Working Group. It represents experts' opinions and not official positions of individual Member States, countries associated to the EU RTD Framework Programme or the European Commission.

Table of contents

1. Executive summary

The European Union (EU) has decided to move towards a worldwide leading knowledge based economy. Part and parcel of that goal is to increase international exchanges and cooperation among students, scholars, and researchers and stimulate international cooperation of scientific inquiry. While past interchanges have taken place mainly among the OECD countries, the rapid advancement of the emerging economies has created a need to evaluate the past programs in order to possibly engage in new and bolder approaches of S&T cooperation with the BRICS countries in general and India in particular.

This study reviews the increasing number of programs executed and resources allocated by both, the European Union (EU) and its individual member states (MS) and associated countries (AC). It puts special emphasis on the link between science, technology and innovation and their relevance in the overall economic and social development context of India and the EU.

India has a long tradition in supporting S&T development, and the country has centres of academic excellence with a world wide reputation. In the early years of the Republic, policy makers were aware of the need to link science with innovation and supported a number of institutions to be engaged in scientific and industrial research. However, the scientists had little if any contact with industry, which lagged far behind competitors of other emerging economies until the 1990s. Since then, the country's innovation conditions have become more favourable in several ways.

First and foremost, India has switched from an inward directed import substitution strategy to an outward direct more open approach, which has affected science and industry almost immediately.

Secondly, India has a large and growing number of English speaking skilled scientists and engineers as well as technicians and managers, whose actual and potential contribution to S&P development has been recognized around the world.

Thirdly, both the public and the private sectors are engaged in raising R&D expenditures. The goal is to more than double the country's R&D intensity from 0.8 % during the last 5 years to 2% by 2012.

Major recommendations of the OMC Working Group on Internationalisation of R&D

The following major recommendations are given by the OMC Working Group. They are addressed to the EU Member States/Associated Countries and the European Commission in order to have them strengthen S&T cooperation with India. The recommendations are divided into those directly targeting S&T cooperation with priority partner countries in general and those that are specifically relevant for the Indian case only. A more elaborate and detailed version of the following recommendations can be found in Chapter 7.

I. Recommendations targeting at S&T cooperation with India and other priority partner countries

Fostering a knowledge-based strategic agenda-setting

It is recommended to:

- deepen the knowledge-based dialogue between the EU Member States and Associated Countries on S&T cooperation with India as a strategic partner of the EU.
- complement the ongoing S&T dialogue between the European Commission and India with an S&T dialogue between the EU MS (and possibly AC) and India, following the high-level strategic forum on EU-India S&T cooperation in February 2007. Such a dialogue should aim at identifying joint interest beyond the themes of the EU RTD Frame-

work Programme and at fostering coordination of concrete implementation measures building on MS´ (and AC´) instruments.

- make regular use and ensure a proper dissemination of results of completed or ongoing EC-funded coordination and support projects targeting India.

Offering an optimum framework for S&T cooperation and removing barriers

It is recommended to:

- examine how well known existing good practices in funding schemes can be implemented at the individual EU country as well as the Community EU level for joint S&T of MS´/AC´ with India and introduce advanced schemes where gaps are found on MS´/AC´ and Community level, aiming wherever possible at reciprocity.
- move towards a more flexible, simplified and harmonized cooperation framework through Community S&T agreements in order to overcome present barriers.
- stimulate an open but coordinated dialogue between European and Indian public and private S&T and innovation stakeholders on themes relevant for the framework of S&T cooperation.

Putting emphasis on the "human dimension" through brain-circulation

It is recommended to:

- increase brain-circulation between the EU and India through promoting the opportunities, advancing funding schemes and removing still existing barriers. New concepts should be developed on national, bilateral and Community level for enhancing outward mobility of researchers from EU-MS/AC towards India.
- consider offering return - fellowships for high-qualified Indian scientists by MS/AC. At Community level the introduction of return fellowships for Indian scientists as a new component of the Marie-Curie programme should be seriously considered.
- attract the interest of Indian students and researchers who are supported through European fellowship programmes at national or Community level to work in Indian branches of European industries through dedicated promotion campaigns.
- analyse the impact of the European Visa Directive in order to prepare the ground for a better access of Indian scientists to the European Research Area.

II. Specific recommendations targeted at S&T cooperation with India

Strengthening brainpower attraction and circulation

It is recommended to:

- increase the promotion of EU programmes at Community (Erasmus Mundus, Marie Curie) and MS´/AC´ level dedicated to bringing more Indian students and researchers to European institutions.
- start at undergraduate level and attract India's large number of well qualified high school graduates, who have difficulties in being accepted at the few Indian top institutions.
- promote Public-Private Partnerships for the establishment of European institutions of higher learning and educating young scientists in India at European standards.

Enhancing strategic S&T cooperation and advancing the instruments and institutions

It is recommended to:

- strengthen the links of MS/AC´ institutions to applied scientific institutional stakeholders of India’s innovation community such as the Council for Scientific Industrial Research (CSIR) to develop a common framework. Wherever appropriate, coordinated activities of the MS/AC should be considered in order to allow a better trans-European networking of innovation stakeholders.
- analyse options on MS/AC level of joint EU-India efforts to transferring science to innovation and to strengthen joint industry oriented research among others through financial intermediaries and the European Business and Technology Centre (EBTC). Setting-up a joint EU-India task-force on industry oriented research with participation of industries from both sides.
- set-up on Community level a joint group of high level European and Indian scientists to provide strategic experts´ guidance for future directions on topics (such as environmental sciences) and most appropriate formats of S&T cooperation.
- put the S&T cooperation into a wider policy framework and foresee a trans-sector policy coordination within EU-India’s overall partnership.
- coordinate, wherever appropriate, national or bilateral activities of MS/AC towards/with India respecting the principle of variable geometries.

2. Introduction

For over 40 years after reaching independence India's policy makers attempted to govern a population, which increased from less than 500 million to over 1 billion, living in diverse regions of a subcontinent through an intricate system of controls and incentives, which led to slow and uncertain progress. When a youthful prime minister took over in the late 1980s, his team started to introduce gradual reforms, which were reinforced by a foreign exchange crisis in the early 1990s. Since then, the economy has moved at an unprecedented scale. Among the outstanding results of those efforts is not only accelerated economic growth, but also the reduction of poverty and malnutrition, and improved literacy and health conditions.[1] In addition, the country has "emerged as a global player in information technology, business process outsourcing, telecommunications and pharmaceuticals."[2]

Looking into the future, the current Trend Chart on Innovation Report for several Asian countries puts India in the category of a likely global player with a crucial role in science, technology, and innovation.[3] In order to make that happen, Indian policy makers will have to tackle quite a number of challenges. They range from the need to upgrade infra-structure over the requirement to further strengthen educational institutions and programs to ways of absorbing and diffusing knowledge in a greater number of sectors and regions of the country.

While keeping strenuously independent, Indian governments have actively searched and received external assistance, both in technical and financial terms over the last 60 years. India was the first developing country to get multilateral aid from the World Bank and later the Asian Development Bank, and bi-lateral support has been strong ever since India's first Prime Minister Nehru had foreign companies help him building up India's steel and other key industries. As time went by, many projects have been executed in coordinated fashion through bi- and multi-lateral agencies. Those include an increasing number projects supporting India's science and technology complex. As a consequence, joint EU projects, which have a somewhat shorter history, should contribute to fit in well not only in support of India's scientific and technological development, but also to an increased interchange of scientists, researchers and students, benefiting both regions.

This report will discuss those issues and challenges of India's scientific and technological development. We will start with an analysis of the structure and actors of the national science and technology (S&T) system with some emphasis on the ongoing efforts in its information and communication technology (ICT) sector and then look at the nation's objectives in the S&T field, examining strategies and policies as well as implementation of programs at the national and international level. The second part will examine India's S&T exchanges, interactions and relations with industrialized and developing countries in general and the EU nations in particular. From that analysis should emerge a number of lessons and recommendations which should help the EU to shape its future S&T policies and activities towards India.

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1 Topalova, Petia. (2008), India: Is the Rising Tide Lifting All Boats? IMF Working Paper No 08/54.

2 World Bank (2007) India Country Overview, www.worldbank.org.

3 Inno-Policy Trend Chart (2007). Policy Trends and Appraisal Report: India. Summary Report. http://www.proinno-europe.eu/index.cfm.

3. India's S&T system and its role in a dualistic economy

3.1. India moves: Results and limitations of recent reforms

Since the independence of the country in the late 1940s, Indian policy makers have followed a two pronged approach towards development in general and science, technology development and innovation in particular. While attempting to catch up with the fully industrialized countries by getting foreign companies to transfer technology - first to public later to private enterprises – many policies and programs have aimed at developing technologies endogenously by public sector research organizations to support the small and medium sized enterprises in agriculture and industry.[4]

Those policies were part and parcel of a development strategy, which was following a statistic approach towards economic development, in which a series of 5 year plan determined the allocation of resources by the central government and in which public enterprises dominated the industrial development of the country. High barriers to imports and disincentives for exports led to an inward directed development process, which resulted in low growth of output and employment and with it a continuation of wide scale poverty within the country.[5]

While agricultural research and development had led to a breakthrough in wheat and rice production, making it possible to overcome periods of severe food shortages in the country and eliminate famine in the 1960s and 1970s, it was not before the late 1980s that the governments under Rajiv Ghandi and Narasimha Rao decided to gradually open up the economy and with it stimulate not only foreign trade and investment, but also a freer exchange of innovative practices in public and private enterprises, which had a positive impact on economic growth and employment creation. GDP growth per capita has accelerated from an average of 3.8% in the 1980s to 4.4% a decade later and exceeded 7% in 2005/2006.[6] Poverty has been reduced, though it remains a major issue, since the accelerated growth mainly benefits the new professional classes in the big cities and a number of dynamic states and has left hundreds of million people still impoverished at the countryside.[7]

Population growth has decelerated from 1.7% in the late 1990s to 1.4 % in 2005/06, but over a quarter of the population is still living below the national poverty line, with agriculture still employing nearly 60%. Growth has been most rapid in the service sector, which has picked up strongly and further increased its share of GDP from 50 to 55% between 2000 and 2006. Industrial growth has also accelerated from 6.3% in the 1990s to an estimated 8% in 2005/06.[8] India's export development, which had been sluggish for many years, losing consistently its share in world markets until the late 1980s, has also improved considerably. In addition to expanding its range of exports from such traditional products as textiles and clothing to automobile parts and pharmaceuticals, India has become a major exporter of software services and software workers, providing not only export revenues but also increasing value added to the domestic economy.

The role of technology intensive sectors in that extra-ordinary rapid expansion of the Indian economy is evident from the rising shares of services in the economy in general and the ICT services in particular, as is the predominance of those industries in output and exports which have undergone the most intense technological innovations, of which pharmaceuticals and chemicals and to a lesser extent automobiles and electrical and electronic equipment manufacturers are leading ex-

4 For a good introduction into that strategy see, Ashok Desai (1984) India's Technological Capability – An Analysis of its Achievements and Limits, Research Policy 13: 303-310.

5 For a full scale analysis of India's postwar development pattern and eventual crisis, see Bimal Jalan, (1993) India's Crisis: The Way Ahead. Oxford Paperback.

6 World Bank (2007), Development Indicators Database, http://devdata.worldbank.org.

7 For the regional impact of the new growth, see J. Sachs et al. (2002) Understanding Regional Economic Growth in India, Harvard University, CID Working Paper No. 88.

8 World Bank (2006) India's Employment Challenge: Creating Jobs, Helping Workers. Report 35772-IN, Washington D.C.

amples. The latter ones have – similar to the ICT industries and services – benefited from a more responsive technological infrastructure and innovative policy schemes.

Observers of India's rise to international importance cite the growing amount of scientific accomplishments. Examples of praises like the following two quotes are common: "The impact of the IT industry on the economy has been enormous (…) India has a thriving pharmaceutical industry. And biotech is taking off. The hope among some senior scientists and officials is that India can short-cut the established path of industrial development and move straight to a knowledge economy."[9] Similarly statements on foreign investment in R&D: "Lately India's manufactured exports have risen…as multinationals invest more heavily in India as a manufacturing base. In India, the early players are interested in the talent pool of chemists, designers and engineers, not low-skilled labor".[10]

Despite recent rapid expansion in economic output and employment and its large number of highly skilled personnel, its is important to realize that the Indian economy is characterized by strong dualism, with a large part of the population still being marginalized, while a growing middle class is establishing itself in the rapidly growing cities. Based on the National Statistical Office's population censuses and the Annual Survey of Industries the following facts emerge:[11]

- Roughly 50% of workers are self-employed. With the bulk of self-employment being in low-productivity subsistence agriculture and services.
- The formal sector accounts for just 11% of a workforce of roughly 460 million; 89% of workers are in the informal sector.
- In agriculture, only 1% of employment is formal, and even in manufacturing the share is just 19%.
- Most formal employment (66%) is in the tertiary or services sector, in which government accounts for the majority.

That means for Indian policy makers it is paramount not only to encourage excellence in high tech industries but also further inclusive, pro-poor innovation, requiring further expanding and strengthening the educational system, improving soft- and hardware infrastructure, and enhancing innovation finance and technical support.

3.2. R&D institutions and their knowledge inputs & outputs

By international standards, India's research strengths include mathematics, theoretical physics, engineering sciences, chemistry, molecular biology and biotechnology, nanotechnology, information technology and space research. Concomitant with India's concern to upgrade its vast underdeveloped primary sector, agricultural research comprises a much larger share in India than the international average. India's scientific talents and accomplishments have been recognized for centuries, and the country's first prime minister after Independence made sure that the government fully supported the infrastructure for the further development of science and technology in the early post war period. While that support was given to both, universities and basic scientific research as well as specific scientific institutions of applied research, the link between the activities of the latter institutions and India's producing sectors has been weak and in some cases non-existent. Moreover, the public R&D system is fragmented, with too many government agencies, organizations and structures aiming to tackle the various challenges simultaneously with little or no coordination with processes which are "slow, bureaucratic and hierarchical."[12] A short survey of the major institutional setup of the public sector research institutions is provided in the Figure 1.

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[9] New Scientist, 19 March 2005.

[10] Newsweek, 7 March 2005.

[11] Dutz, op.cit., p.3.

[12] Ibid., p.10.

Figure 1: S&T system in India

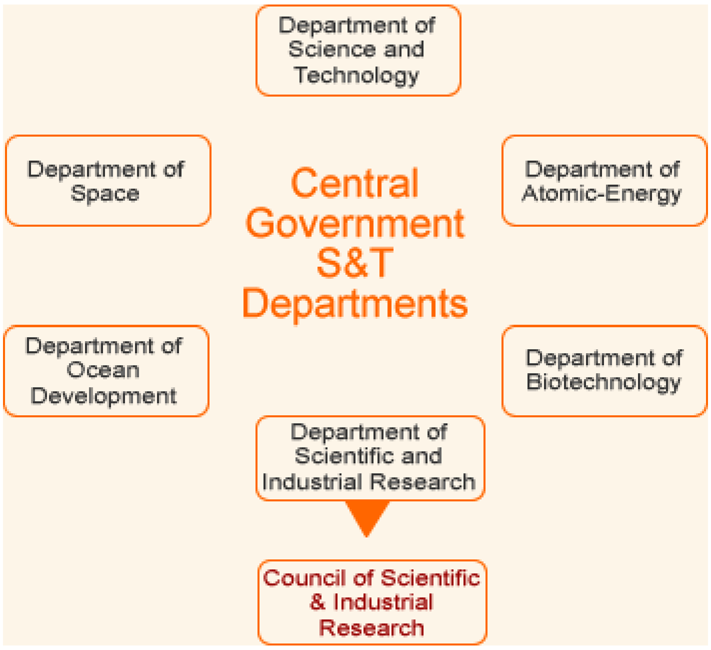
Source: NSTIMS (2006)

The history of the Council of Scientific and Industrial Research (CSIR) provides an example of those problems summarized in Box 1 of the Annex. However, the recent changes also illustrate how the reforms are dramatically transforming those public laboratories and research institutions. As discussed in some detail below, the drivers of that change have been internal as well as external. The world wide revolution of communication and information industries and the concomitant international flow of skilled manpower and investment capital are now joined by stakeholder pressure and of India's policy makers' deregulation policies which have been gradually introduced in the last 15 to 20 years.

Since Independence, the Government of India has been acting as the main policy and decision maker in technology development and thus plays a major role in the National Innovation System (NIS). The Government's efforts have concentrated on the creation of an indigenous S&T base on the one hand and on the supporting of a few high-tech industries led by the IT sector on the other. While the Planning Commission has been actively engaged in budgeting and outlining major guidelines of R&D as well as advising on technology matters, a single plan on innovation or a precise approach on innovation is missing.

The main responsibility for organizing, coordinating and promoting S&T activities as well as international cooperation lies within one Ministry, the Ministry of Science and Technology (MOST) (http://www.mst.nic.in). Almost all of the organisations dealing with innovation in India are under the aegis of this Ministry. MOST is in charge of the Department of Science and Technology (DST), the Department of Scientific and Industrial Research (DSIR), the Department of Atomic Energy (DAE), the Department of Space (DoS), the Department of Biotechnology (DBT), and the Department of Ocean Development (DOD) (see Figure 2). MOST's objective is to promote new areas of Science & Technology and to play the role of a nodal department for the governance of S&T activities in the country. Under MOST, the newly established National Innovation Foundation is the only governmental institution whose sole purpose is the promotion of innovation in the country.

Figure 2: Central government S&T departments



Source: NSTIMS (2006)

As pointed out above, the public sector in 2002-2003 has accounted for 67% of the total national R&D expenditure. In fact, major scientific agencies accounted for a share of 84% of the total government R&D expenditure including public sector in-house R&D units. Five major scientific agencies, the Defence Research and Development Organisation (DRDO), the Department of Space (DOS), the Indian Council of Agricultural Research (ICAR), the Department of Atomic Energy (DAE), and the Council of Scientific Industrial Research (CSIR) account for close to 90% of total R&D expenditure under the central government major scientific agencies, with the DRDO alone accounting for a share of just over 30 % (see Table 1).

Table 1: Share of R&D expenditure by major scientific agencies 2002-2003

Scientific Agency	Percentage
Defence Research and Development Organisation (DRDO)	30.3
Department of Space (DOS)	21.3
Indian Council of Agricultural Research (ICAR)	13.5
Department of Atomic Energy (DAE)	12.2
Council of Scientific and Industrial Research (CSIR)	9.4
Department of Science and Technology (DST)	5.0
Ministry of Environment (MOEn)	2.6
Department of Biotechnology (DBT)	1.6
Indian Council of Medical Research (ICMR)	1.6
Department of Ocean Development (DOD)	1.4
Ministry of Information Technology (MIT)	1.0
Ministry of Non-Conventional Energy Sources (MNES)	0.1
Total	100.0

Source: NSTMIS (2006)

The DST is primarily entrusted with the responsibility of formulation of S&T policies and their implementation, identification and promotion of thrust areas of research in different sectors of S&T; technology information, forecasting and assessment; international collaboration, promotion of science & society programmes and coordination of S&T activities in the country.

The major organisation under DSIR is the Council of Scientific and Industrial Research (CSIR), with its 40 institutes dedicated to research and development in well defined areas and around 100 field stations. Among the other programmes of DSIR are: support to R&D by industry, programmes aimed at technological self-reliance, schemes to enhance efficacy of transfer of technology and a National Information System for Science and Technology (NISSAT).

Traditionally, research in science and technology in India has been government-led. Currently, two thirds of gross domestic expenditure on R&D (GERD) is directly funded by the central government, with an additional 9% coming from state governments, and 5% being funded by the higher education sector. Only 20% are financed by the private sector. In 2004, GERD amounted to US$ 5.9 billion.[13]. Between 1995 and 2004, the average nominal growth of Indian GERD was more than 13% per year. Thus, according to the size of the country, India ranks on 8th position among national R&D expenditures in the world. However, India's R&D intensity, measured by GERD as a percentage of GDP is below 1%, and it declined slightly after 2000 since strong economic growth outpaced R&D expenditure advances. As consequence, the R&D intensity stayed at a relatively modest level of only 0.8 %.

In 2004, India counted over 117 thousand scientists and engineers doing R&D. While large in absolute size, demand has outstripped supply, leading to shortages of skilled engineering and scientific personnel in recent years. Unlike India's growth of R&D expenditures, the number of researchers declined between 1995-2004, reflecting the reform process of major research institutes, which shifted from a very labour intensive to a more capital intensive investment and modernization move, which meant more attractive salaries for qualified staff and reorientation and/or retirement of less productive employees.

The common and still very rough indicators for outputs in the S&T field are patent applications granted by the EU and US Patent Offices and scientific and technical journal articles. During 2003/4 Indian scientists and engineer published close to 13 thousand articles, which was half of Chinese output, but was accomplished at greater efficiency, if measured by US$ costs per article published.[14] A very thorough study by the National Institute of Science, Technology and Development Studies (NISTADS) came to similar results. With India policy makers demanding greater emphasis on measurable results from S&T institutions in the last 20 years, scientific publications have risen rapidly.[15] While India has a strong institutional base for S&T research, the majority of the institutions were found to be of medium or low productivity, i.e. still not very actively pursuing publications, or publishing in no impact journals. Chemistry, Physics and Engineering were characterized as highly productive areas of research, while surprisingly Mathematics and Computer Science were less productive. Indian scientists also proved to be increasingly present at the frontier and emerging sciences, such as biotechnology, drugs and pharmaceutical research, material sciences and medical sciences. Last but not least, India’s collaborative research output has grown faster than the overall expansion of scientific publications. Because of its specific importance for EU- India S&T cooperation, it will be discussed in more detail below.

Table 2: Chinese and Indian patents received at the EU- und US-patent offices

	EU-Patents China	EU-Patents India	US-Patents China	US-Patents India
2006	113	106	970	506
2005	82	75	565	403
2004	69	70	597	376
2003	46	56	424	356
2002	26	18	390	267

13 In purchasing power parity that amounted to over $20 billion. National Science and Technology Management System (2006). Statistics 2005. Government of India, Department of Science, Technology and Development.

14 The numbers were US$462 for India, US$953 for China and US$1.5 mil. for the USA, computed from the World Bank’s Kam Exercise; see http://www.worldbank.org/kam.

15 B.M.Gupta and S.M. Dhawan (2006). Measures of Progress of Science in India. New Delhi: NISTADS.

2001	10	10	265	180
2000	11	7	162	131
1999	7	9	99	114
1998	7	8	88	94
1997	3	8	66	48

Source: EU-Patent Office and US-Patent Office, Annual Reports.

In the case of patents received by the major two patent offices in Europe and the US, India started on a very small level, but increased its applications rapidly leading to a substantial rise in official patents granted, which past the 600 mark by 2006 (see Table 2). While China passed the 1000 mark, similarly to the earlier observation considering costs of achieving those goals, India again was ahead by spending only one third per patent granted.

3.3. Innovation industries and their impact on S&T development

India's ICT capabilities and its presence in the world market for ICT software and services are well documented.[16] The IT software and service sector has sustained an annual compound growth rate of over 45% during the last decade which has been unprecedented in any of the other sectors of the Indian economy. As a result the ICT sector contributed about 22% of total export earnings and provided employment to over one million people in 2004. India exports ICT software and services to about 133 countries, and over 300 Fortune companies outsource ICT services to Indian companies.[17]

A high proportion of Indian software companies are engaged in developing software applications for the banking, manufacturing, communications, retail and distribution, and government sectors. Emerging areas of software applications development include hotels, insurance, and transportation. More important for the development of the science and technology field, the national ICT related system of innovation in India has evolved over time and has been instrumental in the creation of an extensive infrastructure base for the development of other innovative skill-intensive activities. This includes one of the largest and most expanding mass of technically trained manpower, a network of centres of international reputation in natural sciences such as the Indian Institute of Science, the Indian Institute of Technologies (IITs), national laboratories and a number of Software Technology Parks to facilitate the export of ICT software and services.

A second field of rising importance in S&T development is the health sector. Pharmaceutical companies from India produce generic drugs and the enactment of the Indian Patent Act of 1970 allowed Indian companies to take new drugs developed abroad, use the “reverse engineering” process and develop generic drugs until 2005. This has resulted in an enormous growth in the number of pharmaceutical manufacturing companies, accompanied by an increase in investment in the pharmaceutical sector from $250 million US in 1973 to about $1 billion in 2002-03.[18] With competitive pricing of the generic drugs Indian pharmaceutical companies export those to about 200 countries and have become a major source of supply for critical drugs in the national and global markets.

Today, India pharmaceutical ventures account for more than 20% of the world’s generic drug production. Local companies control about 75% of the Indian market, up from 30% in 1972. Up until recently, however, the Indian pharmaceutical companies did not worry about developing new drugs through internal R&D. The lack of scientific knowledge, personnel and copyright law required for successful new drug discovery did not become a priority until India became a signa-

16 R. Heeks (1996). India’s Software Industry State Policy. Liberalization and State Policy. Liberalization and Industrial Development, New Delhi: Sage Publications; N. Kumar (2001). Indian Software Industry Development: International and National Perspectives. Economic & Political Weekly. 36(44).

17 Ibid., pp. 56-57.

18 A.Lackdawala (2007). Indian Pharma Sector. Evolving to Innovation, Pharmaceutical Technology, Vol.31.4: p. 88.

tory to the World Trade Organization (WTO) in 1995 and the obligation to implement a product patent regime in 2005. That meant a paradigm shift from process to product innovation. Larger Indian pharmaceutical companies began investing in new drug discovery by pursuing and realizing research alliances with global firms.

In addition to the private pharmaceutical companies, there are public institutions organized by the Council of Scientific and Industrial Research (CSIR) and the Indian Council of Medical Research, which are also involved in the discovery of new drugs. As a result, both the private run and public companies increasingly contribute to the global patent applications. In the time period between 1995 and 1999 public and private enterprises filed 56 patent applications that increased to 246 patent applications between 2000 and 2004. Despite that increase, Indian companies still spend a relatively small fraction of their revenue on R&D, that is, Indian companies invest 2% on R&D compared with an average of 18% by the TNCs.[19]

There is now a major shift from chemistry driven drug development to biology-based drug development. The so-called biopharmaceuticals are medicines derived from living cells and include such end products as insulin and human growth hormones. The Indian biopharmaceutical market is growing at about 30% a year and the government support for the medical biotechnology industry has increased by 69% between 2001 and 2005. According to the National Biotechnology Development Strategy, the entry of biotechnology into the pharmaceutical industry will enhance the innovative ability of the generics producing Indian drug industry and contribute to the transformation of the sector.

To further stimulate the development of that branch, the Indian government has reduced import duties encourage imports of capital goods and raw materials required for the biomedical research. Different government institutions and universities support the education system in the area of biotechnology. The Indian Institute of Science in Bangalore offers postgraduate courses in Bioinformatics and the Jawaharlal Nehru University in Delhi offer PhD programmes in life science and biotechnology. Many of the new start up companies in the biopharmaceutical sector have entered alliances with public sector institutions for transfer of technology. Encouraged by the government which is interested in maintaining top scientific personnel in the country, Indian scientists from leading institutions are also actively running their own companies, as has been the case of the ICICI Knowledge Park in Hyderabad. (see Annex).

19 The government of India encourages innovation by providing fiscal incentives to R&D companies. These companies benefit from a write-off of 150% on their R&D expenditures, and it is proposed to increase that to 200% for companies meeting specified norms, such as investing more than 3% of sales in R&D, employing more than 200 scientists and applying for more than 10 patents, resulting from research conducted in India. See, Lakdawala (2007), p 23.

3.4. Long term plans and policies for S&T development

Unlike China, India's policy makers have not produced a grandiose long term plan for S&T. However, India's Planning Commission has been responsible to issue consecutive 5-year plans since Independence, all of which contain an important section on S&T, discussing accomplishments and issues in that field during the past 5 years and suggesting new initiatives for the new planning period. Following National Innovation Foundation call for a national policy on innovation, which is recognized by the Indian Government, all current policy documents and plans placate innovation as a key component. That includes the S&T section of the 11th Five-Year-Plan (2007-2012), which is now entitled "Science and Innovation," giving a special thrust to the need to connect between science and the productive sectors and with it using the strong institutional S&T framework built in post-independent India more effectively. Two other major visions and policy proposals, which have been elaborated with the support of Department of Science and Technology (DST) regarding science, technology and innovation in India, are Technology Vision 2020 and Science and Technology Policy 2003.

Technology Vision 2020 is the umbrella strategy initially prepared by TIFAC, The Technology Information, Forecasting and Assessment Council of DST under the chairmanship of Dr. Abdul Kalam, India's most famous nuclear scientist and former President. The document lays out the objectives and actions for India to undertake in order to become a fully developed country by the year 2020, not only in terms of technological development, but also overall economic and social development. In working with many panels and in small groups, the Technology Vision 2020 exercise covered more than 100 areas of concern directly involving around 500 members form Industry, Government, R&D Institutions and Academia and indirectly involving around 5000 nation wide experts through questionnaires and interviews. Five areas were identified based on India's core competence, natural resource endowments, and talented manpower. They include:

- Agriculture and food processing - with a target of doubling the present production of food and agricultural products by 2020. Agro food processing industry would lead to the prosperity of rural people, food security and speed up the economic growth;
- Infrastructure with reliable and quality electric power including solar farming for all parts of the country, providing urban amenities in rural areas and interlinking of rivers;
- Education and Healthcare: To provide social security and eradication of illiteracy and achieve health for all;
- Information and Communication Technology: Considered a core competence and wealth generator. ICT can be used for tele-education, tele-medicine and e-governance to promote education in remote areas, healthcare and also transparency in the administration;
- Critical technologies and strategic industries witnessed the growth in nuclear technology, space technology and defence technology.[20]

The Science & Technology Policy 2003, developed by the Department of Science and Technology, also provides a road map for integrating science and technology directly with societal concerns.21 Keeping in view these broad objectives, the document spells out an implementation strategy that will enable identification of specific plans, programmes and projects, with clearly defined tasks, estimates of necessary resources, and time targets. The broad objectives of the Indian Science and Technology Policy include the same areas as the Vision 2020 and add more general objectives ranging from using S&T more effectively to alleviate poverty, ensure nutritional, environmental, water , health energy security, promote the empowerment of women, establish intellectual property rights to making sure "that the message of science reaches every citizen of India and to make it possible for all people to participate fully in the development of science

20 See: http://www.indiavision2020.org/whatis_2020.htm.

21 Department of Science and Technology (2003). S&T Policy 2003. http://www.dst.gov.in/stsysindia/stp2003htm.

and technology and its application for human welfare. Science and technology will be fully integrated with all spheres of national activity."[22]

Keeping those broad objectives in mind, the Indian Government has put forward an implementation strategy that enables the identification of specific plans, programmes and projects, with clearly defined tasks, estimates of necessary resources, and time targets. The Strategy and Implementation Plan of the Science and Technology Policy 2003 includes a list of 13 major objectives, ranging from optimal utilization of existing infrastructure and competence and generating new funding mechanisms for basic research over human resource development and promotion of innovation to technological development, transfer and diffusion and fostering international science and technology cooperation.

India's private sector as represented by the All India Management Association also engaged in an intense dialogue with government officials and scientific institutions to pursue a pragmatic plan and policy to not only strengthen S&T development but in that process also increase employment and widen the opportunities to modernized and advance for the numerous small and medium enterprises. Entitled **"**India's New Opportunities – 2020 – 40 Million New Jobs **-** $200million New Revenues," the major objective is indeed to first and foremost strengthen those hi-tech industries which can generate new jobs rapidly and then to make sure that enough enthusiasm and agreement is achieved to implement that program. The report makes clear that India can expect to have a potential surplus of population in working age group by 2020, which may be badly needed by the European states. The interesting aspect of that scenario is that most experts in that group would not necessarily have leave India and work for those labour deficit nations at home. The importance of that plan for EU-India S&T cooperation in the human resource field is significant and will be taken up in the context of the last section of the study.

In sum, there is now a broad base of policy objectives and strategies, which are supported by a large number of specific programs and projects in India's S&T field. What is missing, however, is follow-up and evaluation. The Members of the Planning Commission have realized those shortcomings and have noted in the discussion of S&T policies in the 11^{th} 5 Year Plan that there is need for "greater accountability, administrative efficiency and flexibility," all for which the Plan will make resources available to further those goals.[23]

3.5. Private sector interactions and FDI

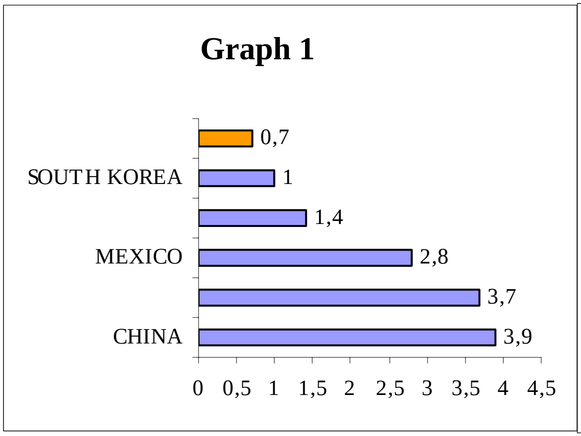
India has had its share of restricting the flow of foreign capital, and although reforms since the mid-1980s have liberalized India's FDI regime, India was still far below the amounts and GDP shares of its major competitors earlier in this decade, as shown in Graph 1. However, the latest official data indicate that FDI which mainly went into electrical equipment, telecommunications, real estate and construction, and particularly the IT service sector, have substantially increased between 1999 and 2007 from US$ 2.2 billion to close to $20billion. [24] Three major issues would seem to have been important in explaining the modest FDI during most of the last decades. The first problem is closely related to the restrictive foreign exchange regime. The second is exemplified in Graph 2, showing how much longer it takes to enforce a contract in India than in many other emerging economies. In the Bank Group's annual survey of "Doing Business," similar problems of delays, non-responsiveness, and other bureaucratic hurdles are examined and found to be still more pronounced in India than many other developing countries, which would seem to have fewer talented people working in government. The third issue concerns infrastructure bottlenecks, which are continue to increase business costs unnecessarily.

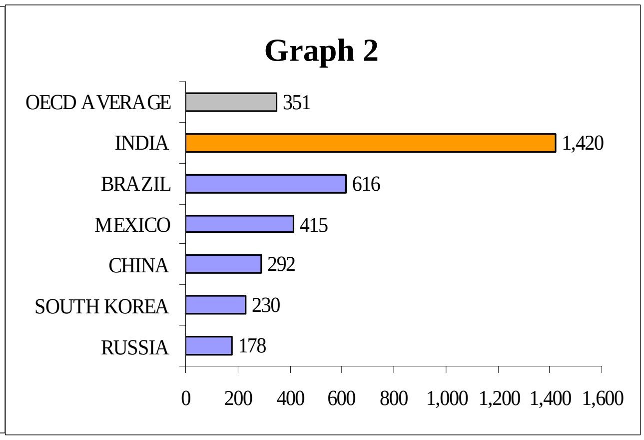
22 Ibid., p.4.

23 See: http://planning commission.nic.in/plans/planrel/fiveyr/11^{th}/11deafault.htm, p. 166.

24 Government of India (2008). Fact Sheets on Foreign Direct Investment from August 1991 to May 2008. Delhi and Mumbai.

Graph 1: Gross Foreign Investment/GDP (percent), 1994-2003 average
Graph 2: Time to enforce contracts (days), 2006





Source: World Bank (2006) World Development Indicators; World Bank (2006) Doing Business in South Asia

The recent turnaround is closely linked to India having arrived at the world scene as a country of innovation. Among the clearest signs are the productivity increases and jobs created in information technology (IT) and IT-enabled services and business process outsourcing, and in sectors that have benefited from the most openness to free trade and FDI. The national innovation plans and program discussed above have become believable by foreign and Indian investors and provided the impetus and the opportunity for more Indian enterprises to benefit from global knowledge through greater openness in trade and FDI.

In the last few years over 300 transnational corporations (TNCs) have been setting up R&D and technical centres in India. They employ 80,000 plus scientists and engineers. Current spending is about $4 billion a year and further investment plans have come close to US$5 billion.[25] The United States accounts for more than half the number of companies and 72% of the investments. Others key countries include South Korea, Germany, Denmark, and the United Kingdom. According to the 2005 TIFAC Report on Foreign Direct Investment in R&D, companies from EU member and associate countries had established close to 30 R&D Centres in India by 2003, which was less than the 53 US Centres, but clearly ahead of the 12 East Asian ones.[26] Almost half of the centres have been installed in Bangalore, followed by Delhi and Mumbai. Most work is concentrated on IT, R&D software, engineering design (automotive, consumer durables, aerospace), chemical design (molecules, chemical structures), and agriculture and biotechnology (seeds, food, enzymes). Between 2000 and 2005, some 415 patents from India have been filed by these firms with the U.S. Patent Office.[27]

From the results of several international surveys, this trend is going to continue, as foreign investors have ranked India as their preferred destination for locating innovation centres.[28] Not surprisingly, it is the English speaking skilled low cost labour force, which is the number one attrac-

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25 Based on Evalueserve (2006) estimates, total private spending on R&D over the two years 2004 and 2005 amounted to $6.75 billion – though no breakdown is available among MNCs, domestic firms and high-tech start-ups.

26 TIFAC (2005) FDI in the R&D Sector. Study for the Patterns in 1998-2003. New Delhi: Academy of Business Studies.

27 See Bowonder and others (2006). “Innovation in India: Recent Trends” Background Paper prepared for the World Bank Environment for Innovation Study. TATAS Mgt. Training Centre. Pune; and TIFAC (2005) FDI in the R&D Sector in India 1998-2003. New Delhi.

28 See for example S. Silverthrone (2005), The Rise of Innovation in Asia. Working Knowledge Papers, Harvard University Business School. Cambridge/Mass. He reports that 69% of firms consider India their preferred site-compared with 8% for China.

tion.[29] The TNCs are choosing one or two of three possible strategies to source innovations in India. Most of them are establishing innovation centres in India through fully owned local subsidiaries; others are outsourcing innovations to Indian research centres and firms, or they acquire innovative firms and start-ups.[30]

In 1991, Indian enterprise R&D spending as a share of sales was less than 0.1%. By 2004 that share was more than 0.5%. Although this was a significant increase in less than 15 years, it remains relatively low by international standards. Most indigenous Indian companies are funding little R&D on their own. Only 3 Indian companies - Ranbaxy and Dr Reddy's Lab in pharmaceuticals and Tata Motors - are among the world's top 1,250 companies when it comes to R&D investment. This development has stimulated to have other domestic enterprises being also increasingly engaged in R&D to shift from adaptation to innovation.

Not surprisingly the leading sectors engaged in R&D are those where India has been facing the most competition from TNCs and the more demanding global market, to which an increasing number of domestic enterprises are now exporting. Pharmaceuticals has been the country's most R&D-intensive sector, with the share of R&D relative to sales jumping from 0.4% in 1991 to 4.8% in 2004. After decades of being involved in "reverse engineering" supported by an indigenous patent law, India's pharmaceutical industry has made the jump to adjust to international patent rules and is developing the capacity to become a major innovator, with the three top firms now investing 12–18% of sales in R&D in 2006.[31]

Rising R&D expenditures are also taking place in the automotive and electronics industries, and a recent survey of executives representing all major manufacturing sectors found that efforts are underway everywhere, with over 80% of business executives believing that generating organic growth through innovation is essential for success in their industry, for which increased investment was planned in the years to come. However, nearly three quarter of the surveyed group maintained that lack of collaboration between industry and research institutes was still the main hurdle to innovation in India. The survey also found that the key challenges faced by companies included measuring returns to innovation, moving quickly from idea generation to initial sales (commercialization and launch), and balancing risks, timeframes, and returns across a portfolio of new projects. These findings imply that better monitoring and management training and tools for innovation are becoming increasingly important for Indian firms.

The net effects of the rapid rise of indigenous and foreign research centres are clearly positive, though the short term impact of the TNC innovation centres have already led to a shortage of skilled technical and scientific personnel and higher costs. While India's large demographic resources should lead to a supply response over the longer term with appropriate incentives for the development of higher-end engineering and science skills, and likely benefits to the Indian economy from greater exposure to global competition, short term effects may well be negative for several domestic firms. In this context, it would be questionable for the government to offer more incentives to TNCs to locate R&D in India. However, greater efforts are required to (1) increase the supply of quality scientists and engineers, as there is clearly an increasing supply constraint that will undermine the growth of R&D by Indian and foreign firms and (2) strengthen the links between the many government research institutions and universities with both groups. Both undertakings could and should be supported by the EU countries to be discussed below.

4. International S&T strategies: Objectives and instruments

While India's policy makers have pursued international cooperation in the S & T field for decades, it is interesting to note that until recently there is scant mentioning of those efforts in India's

29 Annual payroll cost an Indian scientist or engineer is roughly $22,600 a year, compared with $90,000 in the United States-or roughly a quarter of the cost.

30 Bowonder, op.cit., p. 133.

31 Business World, 25 December 2006; These levels are comparable to those of some of the world's leading pharmaceutical firms, such as Pfizer (14.6%) and Glaxo (14.0%).

major policy and strategy documents concerning scientific and technological development. Though spending over 30 pages on Indian S&T development of the past and following planning period, 10th 5 Year Plan (2002-2007) has but a terse paragraph on the role of international cooperation in the S&T field.[32] Similar scant treatment to that issue is devoted in the Vision 2020 paper and the Government's S&T Policies 2003 document, although the latter one acknowledges the importance of international cooperation more explicitly, especially in elevating S&T policies into the political sphere of India's international relations policies.

With the 10th 5 Year Plan (2002-2007), the attention to international cooperation in the S&T field has been specified more explicitly. It is now put into the forefront and is mentioned together with several other priorities in the "renamed" Chapter on "Innovation and Technology." A whole section is devoted to "Leveraging International Collaborative Inputs" which exposes the major rationale behind that endeavour, i.e. "providing first-hand acquaintance with scientific and technological developments and work cultures in other countries and access to sophisticated research facilities abroad."[33]

4.1. Furthering and attracting human resources

Since the independence in 1947, the successive Indian governments have seen education as a crucial development tool. The education policies focused on the establishment of excellence in higher education and inclusion of students at all education levels. While they succeeded in the first goal to a certain extent, the second one has been lagging badly. Those two tasks have now been tackled by the National Knowledge Commission (NKC), which was constituted by Prime Minister Dr. Manmohan Singh in 2005.[34] Focussing on four key aspects of knowledge, which range form enhancing access to creating a world class environment for creating knowledge, the NKC addresses the major issues in ten major recommendations, which start with the legally establishing the right to education over a more diversified educational structure including open and long distance education to the establishment of a high-end national knowledge network. The remainder of this section will explain the education policies of the successive Indian governments with special attention to recent policy initiatives in solving problems of India's brain drain.

The first Prime Minister of independent India, Jawaharlal Nehru, regarded education for all as a crucial tool to unite the country so that India's different communities could contribute to a sense of collective national pride. The formation of higher educational institutions, such as the Indian Institutes of Technology (IITs) and the Indian Institutes of Management (IIMs), was part of a policy to create a modern Indian state. In addition, policies of positive discrimination in education gave unprivileged social groups access to education. However, today India's rise to a global player is not attributed to its education system, including its university system, but to its special S&T institutions. Seven Indian Institutes of Technology (IIT) and six Indian Institutes of Management (IIM) as well the Indian Institute of Science (IISc) and the newly established Institutes of Information Technology (IIIT) and the All India Institute of Medical Sciences (AIIMS) are the leading centres of scientific, technical and engineering excellence in India. Those elite institutions are known to have rigorous entrance examinations to select 1% from close to 400 thousand applicants, and they offer demanding course work. As a result, over 60% of doctorates in sciences and engineering are granted by just about two dozen of those top institutions of learning.

At the turn of the century, the seven IITs turned out about 3000 graduates per year. That is woefully inadequate for fulfilling world wide and Indian demands. Similar to the two-tier character of India's economy, dualism seems also be typical for the education system in general and the higher education institutions in particular. Many of the universities and colleges which supply today India's high tech and modernizing industries lack qualified staff to teach and resources to keep pace with the need of industry to get qualified personnel. As a consequence, engineering industries and

32 India, Planning Commission (2002). 5 Year Plan, 2002-2007, Ch. 10: Science and Technology, para. 10.

33 India, Planning Commission, (2007). 5 Year Plan (2007-2012). Ch. 8 Innovation and Technology, p.171.

34 National Knowledge Commission, Government of India (2008) Towards a Knowledge Society. New Delhi.

software firms are forced to increasingly foster in-house training. In addition to several efforts from industry, the government's Mission REACH program is in the process of creating Centres of Relevance and Excellence in a network of universities. Another initiative of the Ministry of Science and Development to have graduates make the jump from academia to applied research and development is a scheme involving universities helping "techno-entreneurs" identify appropriate networks and academic institutions with appropriate R&D, which can then provide guidance in developing prototypes, filing IPRs, and even finding appropriate sources of finance for commercialization of the final products or services.

Like other developing countries with elite universities and research institutions, India has to deal with the brain drain problem. Although there are no exact data to calculate the loss to India's economy by students staying and working abroad after graduation, the costs have become more significant since India's firms and institutions require an increasing number of highly skilled personnel. Surveys undertaken on Indian PhD graduates in science and technology, who have stayed abroad, show that close to 80% of 1990-91 doctoral recipients were still working in the United States in 1995. While an even higher share of Chinese students stayed on, only 11% of Koreans with science and engineering doctorates from US universities in 1990-91 were working in the United States in 1995.[35]

While that problem has led countries like India to think of some policies to reverse the brain drain. Earlier proposal to establish a compensatory fund for OECD countries returning some of the investment in education to the poorer nations went nowhere, mainly because of multilateral jurisdiction issues. On the other hand, India has developed a number of programs, which were to encourage return migration. The Council for Scientific and Industrial Research (CSIR) was involved in both, a scheme to temporarily and permanently attract Indian scientists and engineers. However, the insufficient financial incentives combined with a very bureaucratic administrative handling of those programs have rendered them quite ineffective so far.

Now there is some evidence of an independent reverse brain drain with a larger number of doctoral students from India pronouncing plans not to stay in the U.S. after finishing their degree.[36] Earlier on, an increasing number of well known medical specialists returned to India. They have been instrumental in building up a vibrant private medical community and a rapidly expanding hospital sector.[37] There are also case studies of successful Indian entrepreneurs in the United States, who have established branches or even firms in India. That, however, is still a drop in the bucket. While it has been estimated that some 1,500 highly qualified Indians have returned from the United States, India registers about 30 times that number of student and scientists departures each year.[38] It would seem that this issue will have to be taken into consideration when joint EU-INDIA action in that area is expanding in the years to come.

4.2. Improving infrastructure

India's infrastructure facilities are strained. Highways, which move about 70% of the goods transported in India, account for only about 2% of the country's 2.1 million miles (about 3.4 million km) of roads. It takes an average of 85 hours to unload and reload a ship at India's major ports, 10 times longer than in Hong Kong or Singapore. Power supply is still unreliable and hampered by insufficient revenues to finance the required investments for maintenance and expansion. Similarly, water supply is hampered by lack of treatment plants, inefficient use especially on the countryside and customers' unwillingness to pay the required fees to maintain the system. While the central government has doubled its expenditures for those purposes, the hundred of billions of dollars required have to partly be mobilized by attracting foreign investment, which has been en-

35 M. Cervantes and D. Guellec, (2004) The Brain Drain: Old Myths, New Realities, OECD Observer. Paris.

36 W.J. Broad (2004). US is Losing its Dominance in the Sciences. New York Times, May 3.

37 EIU, Healthy Growth, Business India Intelligence, January 9th, 2008.

38 Ibid., p.2.

gaged in those ventures for some time in many countries but relatively limited investment in India.

While infrastructure bottlenecks and failures have a direct impact on the environment and the wellbeing of the population, the S&T institutions have done relatively little work in tackling those issues. At this point in time, most foreign investors have also remained hesitant, because the country's institutional structures, capital markets, and possibly even the environment is still ill-equipped to deal with the complications that invariably accompany such large investment projects. India still has rather shallow private sector capital markets, delays in contract enforcement, problem with foreclosures, and little or no concept of large-scale asset securitization to fund the mega projects in the physical infrastructure sectors.

On the other hand, telecommunication, which traditionally was lagging way behind the demands of business and the population has changed rapidly for the better. That sector's kick start came through the introduction of new technology and the mobile telephones, which customers liked and could afford. Serious competition and large investments by Indian as well as foreign firms, which wanted a share of the rapidly increasing customer base, followed. To ensure orderly markets, regulation was enforced administrating a sector which has about 100 million mobile connections and 50 million fixed line connections plus 2 million broad band connections. All this, while Indian telecom voice mobile leased line for data is amongst the cheapest in the world and quality wise improving.

Realizing the need to provide a better framework for domestic and foreign firms in the IT sector, the India Government also supported infrastructure investment in that sector, with the Department of Electronics(DoE) playing an instrumental role, setting up Regional Computer Centres attached to educational institutions which were run like public utilities. Since the late 1980s the DoE has concentrated on providing a data communication and networking infrastructure to the educational and research community and to the software industry. The Education and Research Network (ERNET) project was initiated in 1986 with participation of several Indian Institutes of Technology and regional actors in Mumbai and Bangalore (among others), with the objective of enhancing the national capability in the area of computer communication by progressively setting up a nationwide computer network for the education and research community.

A notable institutional intervention has been the establishment of Software Technology Parks (STP) to provide necessary infrastructure for software export. The first ones were established at Bangalore, Pune and Bhubaneshwar in 1990. As of now there are 39 STPs set up in different parts of the country. They play a significant role in the export of software from the country. The infrastructure facilities available in these STPs include, among other things, modern computers and a communication network. According to the Indian Department of Information Technology the 7000 units registered firms in the STPs accounted for 80% of the total Indian software exports

4.3. Supporting and attracting knowledge-intensive industries from abroad

In developing countries such as India, innovation concerns not only the development of new knowledge, but also relates to the application of existing knowledge which is new in the local context. Attracting global knowledge through channels such as FDI, technology transfer, trade and technology licensing are ways to facilitate technological change and spur innovation. Thus, a policy supporting the inward flows of high tech foreign investment (FDI) can be regarded as part of a country's innovation policy.[39] Until the end of the 1980s, the Indian government was restrictive to inward FDI flows, based on the idea of technological self-sufficiency and imports of foreign technology embodied in capital goods were only admitted if the country needed those goods and could not produce them itself.

Not surprisingly that policy was not very effective. Earlier studies on technology absorption in Indian industry found that, despite the authorities' efforts to direct and control foreign technological inputs, the impact of government policies on the domestic firms' further technological devel-

39 World Bank (2004). India Investment Climate Assessment. Washington D.C.

opment was minor. Immediate goals, such as reduction in collaboration and fees were accomplished, but “they were not very successful in achieving their most important aim, namely a significant increase in technology generation by the firms.”[40]

At the beginning of the 1990s the government started to change its restrictive view. Since then, the government has been performing an active role in promoting FDI in general and investments of technological sophisticated industries in particular, providing tax incentives and streamlined regulatory procedures.[41] As Table 4 in the Annex indicates, the results of that change in policies has been remarkable. Inward FDI flows accelerated from US$2billion in 1999 to close to US$ 17 billion in 2006. In the high tech area, over 70 multinational companies, including Delphi, GE, Hewlett-Packard and Daimler-Chrysler, have set u R&D facilities in India. Together with the laboratories set up before 1997, the total number of R&D facilities owned by MNCs was close to 100 by 2005. They are from such diverse sectors as telecommunication equipment, chip designers, IT hardware companies, medical equipment and durable goods producers, as well as automobiles and pharmaceutical companies. Not all MNC research laboratories are working on developing new technologies at the global technology frontier, but do mainly research on improving existing products. That, however, may have faster and more direct impact on modernizing the sector as well as other parts of the economy.

Realizing the importance of its skilled human resource base in attracting R&D, the Department of Industry and Commerce, which is still responsible for overseeing foreign investment in India, is advertising less that India is one of the major world economies with a potentially large internal market with access to other South and South-eastern Asian markets, but more the fact that India has an abundant, qualified and English speaking workforce and a transparent FDI policies buttressed by the following statistics: In recent years over 200 thousand scientists, engineers, and technicians have graduated from Indian universities every year.[42] Though still modest, the number of workers in applied R&D facilities has been rapidly expanding from 12 thousand in the 1970s to 30 thousand in the 1980s. In 2000, there were about 50,000 professionals working in those institutions doing industrial R&D.[43]

An even more recent trend has been occurring of Indian firms with R&D ambitions investing abroad to get access to firms and human resources not or less available in India. The largest foreign investments from Indian firms were in the pharmaceutical and automotive sectors, which have become the most R&D intensive industries. The country has also emerged as a prime location to conduct offshore R&D.

4.4. Encouraging public-private partnerships in R&D

India’s policy makers’ inclination to support endogenous technological development was strengthened when it became necessary to move from reverse engineering to serious R&D activities once the country joined the WTO. As a consequence a number of programs have been implemented, which went beyond traditional fiscal and monetary incentives. Quite a number of public-private partnerships have formed, which have fostered the linkage between research institutions and industry. Among the more promising undertakings are the Technology Development and Demonstration Programme, the New Millennium India Technology Leadership Initiative and the Drug Development Program. These programs are, however, home-grown with little or no foreign participation and are therefore discussed in Annex 2.

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[40] Ghayur Alam (1988) India’s Technology Policy: Its Influence on Technology Imports and Technology Development. In Ashok V. Desai, ed. Technology Absorption in Indian Industry, New Delhi, Wiley Eastern Ltd., p. 154.

[41] M. Zanatta, and S. Queiroz (2007) The Role of National Policies on the Attraction and Promotion of MNEs’ Activities in Developing Countries, International Review of Applied Economics, Vol.21, 3, pp. 419-435.

[42] C.Dahlman and A. Utz (2005). India and the Knowledge Economy. Washington D.C, The World Bank Institute. Chapter 3.

[43] Ibid. , p.27.

One of the early external programs was initiated in the late 1980s with the World Bank's Technology Development Project, which - besides providing funds for imports of embodied technology and venture capital - supported a research and development fund (R&D SPREAD Fund) promoting industry-sponsored research at public R&D institutions and the IITs. The Fund was managed by a technology oriented unit of ICICI, at that time still India's mostly public premier Development Bank.[44]

Since 1994 SPREAD has funded 120 projects of which close to 50 were completed by 2008, of which two thirds were successful in being commercialized, a significant number for a program which attempted to bring India's public and private sector closer together. Three sectors (pharmaceuticals/bio-technology, electrical/electronics and chemicals and petrochemicals) counted for three quarters of all projects. An evaluation has been undertaken and came to very positive results, especially since over 80% of the companies involved in the program had no previous involvement with the R&D institutions.[45] As a consequence, a follow-up program was implemented, which disbursed over US$15 million between 1994 and 2002.

Since 1992, bi-lateral aid (mostly from the U.S. and Germany) supplied US$ 70million to support SPREAD and more importantly helped to modernize and update facilities, equipment, and organizational structure of India's major research institutes. Out of those CSIR laboratories succeeded to receive funds for 11 projects, with central educational institutes receiving 8 and other government institutions receiving funds for 16 projects. The SREAD Program was not only made possible by government's decision to gradually liberalize the economy, but also by the expressed wish and financial pressure to have the technological institutes forge links with industry. As to its sustainability, the many government sponsored program with similar objectives described in Annex 2 indicate the recognition of the policy makers about the importance of linking S&T institutions with industry. Within that area, the financial intermediary ICICI became a major player, which is highlighted in Box 2 of the Annex.

The recently inaugurated Indo-German Science and Technology Centre (IGSTC) has taken up the idea to actively further the interaction and collaboration of the S&T institutions and industry. Named "2 + 2 Research and Development Projects" a foursome of a research institute from each country and two enterprises from India and Germany will attempt to forge closer links between applied R&D and innovation in such areas as biotechnology and health research, production technologies as well as energy and environmental technologies. Since the signing of the Agreement in 2007, six partnerships have been approved and supported. Germany and India have allocated up to EURO 10 million each for the coming five years.

5. S&T cooperation with India

5.1. Cooperation at EU level

A dynamic and reconfigured global R&D system has posed new challenges for policy- makers who need to solve global challenges with larger and more focused programs. Bundling the knowledge contributions of its members, requires from a community of nations internal coordination by realizing that it has to find more effective ways to organize and coordinate R&D resources and put them to use. Consequently, the EU has been careful but increasingly more active in supporting science and technology development around the world with a number of 4-year Framework Programs (FPs), which started in 1984 and is now at its 7th FP.

Traditionally, EU cooperation, which included S&T programs, concentrated on OECD countries However, more recently the emerging economies have become onto the forefront, with significant increases of contacts between research organizations and programs during the last 10 years. The most rapid rise in links between those institutions during the periods of FP5 and FP6 took place

44 World Bank (1987) Industrial Technology Development Project, Washington D.C., The World Bank.

45 For an evaluation see, F. Najmabadi, and S. Lall. (1995). Developing Industrial Technology: Lessons for Policy and Practice, Washington D.C. The World Bank.

between the EU and Russia, followed by China, Brazil and India. While contacts with India were still absolutely smaller than Brazil, China and Russia, they rose more rapidly in relative terms.

EU-India cooperation in the S&T field has been in existence for decades, but it has been considerably strengthened in the last few years, after a comprehensive Science and Technology Cooperation Agreement was signed in October 2002.[46] That agreement focused on a closer participation of universities, research organization and other institutes and entities in S&T in each other's research projects, including exchange and sharing of equipment, exchange and provision of information and data, visits and exchanges of scientists, engineers and other personnel involved in S&T. The modalities of the implementation of that ambitious agenda were defined by a joint steering committee in 2004. More recently, EU-India S&T Cooperation was reconfirmed and strengthened by India-EU Ministerial Science Conference, which took place in New Delhi on February 7th and 8th, 2007. Tackling the issue of the major economic and societal challenges that the EU and India are confronted with, both partners recognized the importance of a strong science and knowledge base as a major prerequisite for competitiveness. Furthermore, it was agreed that enhancing socio-economic development and tackling global health, environmental and energy issues could only be done through international S&T collaboration.

There is indeed a window of opportunity for a significant increase in the breadth and depth of EU-India cooperation, which include the Indian government's plan to substantially increase R&D expenditures and the launch of the EU's 7th Framework Programme for Research and Technological Development 2007-2013. India is already an important partner for Europe in its Research Framework Programme. More than 100 Indian research institutions have participated in over 80 research projects funded in FP 6 (2002-2006). These projects received more than 250 Million Euros in funding, the share of the Indian partners being 11 Million Euros. Indian organizations have also been active in FP7, which started on January 1st, 2007, with more than 400 research institutions responding to the first set of Calls for Proposals. The evaluations of these calls have taken some time, but contract negotiations for short listed proposals are underway and the results will be known by late 2008.

During the FP6 program period 92 projects with a value of EURO 245.8 million were signed or under negotiation to be signed. As Table 3 indicates, emphasis was put and resources were allocated to leading India R&D institutions and their European counterparts in the fields, information society technologies of life sciences, genomics and biotechnology for health, and especially to sustainable development, climate change and ecosystems. Sustainable development studies in energy and surface transport together with the above mentioned one on climate change add up to the largest chunk of FP6 projects, amounting to 27 projects with 34 participants and to just over EURO 100 million or making up over 40% of the total allocated financial resources.

During the same time period, the Research Directorate General of the EU Commission jointly with India's Department of Science and Technology organized several workshops on priority issues of the Cooperation Agreement, starting with forum on the "Information Society", followed by a workshop on "Climate Change and Natural Disasters ". In late 2004 and early 2005 two further workshops followed, the earlier on addressing issues of "Road Transport Research" and the other "Nanotechnology and Functional Materials."[47]

Table 3: FP6 S&T contracts – signed and under negotiation (contribution by priority area)

Thematic Priority	No. of Contracts *	No. Indian Participants	Amounts Mill Euros	% of All Projects	% EC Contribution to Partners
Sustainable Development, Climate Change Ecosystems	27	34	103.0	41.9	20.5

46 A draft roadmap of the Agreement was drawn up in March 2008, the content of which will be discussed below.

47 EU, Technical cooperation Ventures (2007). http: //www.delind.ec.europa.eu/en/stcoop/stcoop_cli_workshop.htm.

Information Society Technology	14	22	50.8	20.8	27.6
Life Sciences Genomics & Biotech	6	6	27.0	11.0	5.1
Nanotechnology & Nanosciences	4	4	13.3	5.4	3.1
Food Quality and Safety	3	6	11.7	4.8	1.8
Other Areas **	38	64	40.0	16.0	41.9
Total	92	136	245.8	100	100

Source: Extracted from EU (2008) FP6 Indian Statistics

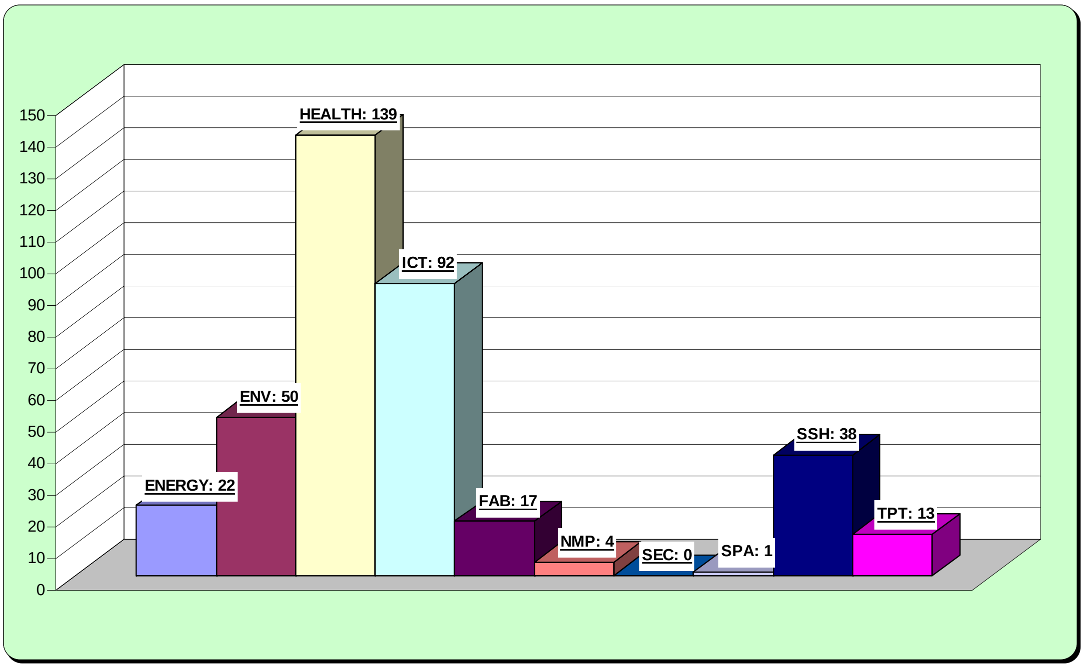
* Contracts with at least one participants from India

** Other areas include specific measures in support of international cooperation such as policy support, research and innovation, science and society

That cooperation program has now been expanded for the current FP7 Program Period. The most frequent themes identified in foresight exercises in several world regions also correspond to major cooperation activities under FP7. They show that Africa expresses a preference for S&T support in the areas of health and social sciences. In Asia, a variety of fields are seen as important in future cooperation with the EU, ranging from environmental technologies over energy and transport to ICT and manufacture technologies. Here, collaborations in social sciences fields and humanities have a lower recognition than in most other regions. North America has a special interest in manufacture and energy related technologies, South and Central America in environmental technologies.

Comparing those preferences to the themes in the EC Framework Program, in which those world regions are part of, there seems to be common agreement that Europe is particularly recognized as a strong research partner in the field of environmental technologies. While it is noteworthy that the other high profile areas ICT and health, which play an important part in third country participation of the EC Framework Program, are less apparent in the top themes chosen in foresight exercises of third countries, those findings are not reflected in recent evidence coming from the first calls for Indian research and study proposals, which have already reached close to 400 in early 2008. Here, health proposals make up 37%, followed by ICT (24%) and environment (13%). That would indicate that the congruence between EU foresight exercises and Indian demands seem to match quite well in those broad areas of S&T.

Graph 3: FP7 - Cooperation first calls for proposals, applications from India and EU partners



Source: EU (2008). Key Figures of EU-India S&T Cooperation (provisional data)

India has had bi-lateral S&T cooperation agreements with all the larger European countries and also the majority of the smaller EU member nations for over half a century. In the case of the UK for even longer. Information based on CREST questionnaires on current activities and agreements in that area show that the bilateral types of cooperation between the EU and India seem to be substantially more active and widespread than is the case with the other BRIC countries. [48] The major programs almost always include fellowship and scholarship programs and joint research and education projects. Only a few EU members also engage in knowledge transfer and business cooperation, most of which is covered by other categories of external aid by the majority of the larger EU members.

Current developments of bi-lateral S&T cooperations are similar, with ICT programs dominating S&T cooperations. This is followed by biotechnology, energy, environment, and materials science. As shown above those are the very areas the EU as a whole has concentrated on, and it might be important to evaluate to which extent the coordination and cooperation between individual countries' programs and those conceived by the EU as a whole are matching up well. This would be especially of value, because almost all countries are planning to enhance the current programs, i.e. allocating more resources to those programs in the future. Again, this puts India in a special position, not shared by Brazil and Russia, where S&T cooperation is stable at best, with a larger number of countries not willing or able to expand their cooperation programs.[49]

Similar to the scant evaluation studies of S&T programs within India, the same seems to be true for its bi-lateral programs with individual EU countries. One of the longest standing bi-lateral scientific cooperations has been the Indo-French Centre for the Promotion of Advanced Research (CEFIPRA) which was established in 1986 and has a proud record of having evaluated nearly a thousand proposals and approved 357 of them, resulting in over 1800 articles published in international scientific journals being approved since then. However, there is no further information about quality of the journals, nor any mentioning of citation. In the cases in which some evaluation was undertaken, it seemed that applied joint research projects/programs – including technology exchange networks and innovation forums are rated highest, with bilaterally funded research fellowships & higher education cooperation coming in second.

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48 European Union, Joint Research Centre, (2008). Analysis of Responses to the MS/AC Questionnaire on S&T cooperation with Brazil, India and Russia, CREST Working Group on Internationalisation of R&D. Seville. JCR.

49 Ibid., pp.6-8.

In setting a joint framework, there was widespread agreement about the major issues to be dealt with in India's case. One of them was the need for improved information on S&T front. Several efforts were undertaken, leading to the establishment of an international European Research Area Network (ERA-NET) which serves as a basis for the coordination of future EU-India programs of S&T cooperation. In February 2007, eight partners from India, France, Germany, the Netherlands, Portugal and the UK joined in a specific support action, called "Action to Observe and Understand Different Approaches in Euro-Indian Research Programmes." (AOUDA). By setting up a strong network of expertise and knowledge for the management of international research programs, it has analyzed the existing bilateral scientific cooperation programs and identified best practice cases, which should be of good use for future EU-India S&T cooperation. Next in line is the concern with stimulating the mobility of researchers. There still is and probably will continue to be a substantial imbalance of many more Indian students and researchers attempting to study and/or do research in European countries than Europeans going to India. Furthermore, European researchers typically stay for only a few days in India, while Indian prefer to stay for two to three months. This is particularly true for science and engineering. Those are fields in which European students and scholars prefer to either study and do research in Europe and/or the USA. However, there are a few centres of excellence in India, and although they are often overwhelmed by the many qualified Indian applicants, stronger links made possible by EU financial support should make for more attractive opportunities of European scientists and engineers to study and do research in India.

In the context of innovation and industry cooperation, one issue is intellectual property rights. While India has adopted legislation which conforms to international rules laid down by the WTO, implementation and application are still uneven in and often not enforced. That is true for medications as well as IT products. Another issue would seem to be to facilitate multilateral initiatives leading to the better use and development of research infrastructures, at EU and international levels. That task is expected to be fulfilled by the European Strategy Forum on Research Infrastructures (ESFRI), a strategic instrument to develop the scientific integration of Europe and to strengthen its international outreach. In that context, a few large scale research projects, such as fission reactor ITER, which has opened up to international participation with Indian scientists participation and the international Facility for Antiprotons and Ion Research (FAIR) are examples of the rising importance of not only pan-European integration, but direct international cooperation of long term and large scale scientific research undertakings.

5.2. Cooperation at Member State/Associated Country level

Collaborative links FP between EU Member States and the BRICS' countries have been strongest with the UK, Germany, France, and Italy. However, smaller countries like the Netherlands, Belgium and Denmark have also made an impact in establishing cooperation agreements, although they are still smaller than the ones they pursue in Russia and China. The history of some individual member countries experience in S&T cooperation in India have been judged very useful by both, the India-EU Ministerial Science Conference in 2007 and by newcomers, who are planning to systematically pursue that cooperation in the future.[50] The major characteristics of those measures include S&T Cooperation Agreements as a basis for the legal and political basis of continuous cooperation, the use of bilateral working groups in order to formulate and adopt relevant cooperation measures, which include discussions of high ranking experts on relevant research areas of joint interest and determination of major themes to be followed in the context of cooperation possibilities within the EU Framework Programs. In addition, establishing a science coordinator in member states embassies in New Delhi as well as conducting workshops to attract attention and interest for bi-lateral cooperation of top scientists were important. Last but not least, programs to stimulate student, scholar, scientist mobility turned out to be fruitful for strengthening bi-lateral cooperation.

The United Kingdom has been the traditional partner for S&T cooperation in India, with many historic institutional links, including graduate education of senior Indian scientists. However, ties have weakened, with few initiatives remaining between the two governments in the 1990s and early years of this decade. This has changed recently. There have been new programs by the British Council and FCO Science and Innovation Network, which promote research collaborations and facilitate technology transfer. A major recent addition is the UK-India Education and Research Initiative (UKIERI), a flagship program to increase research and education links between the two countries. There is now joint funding from major government departments and the private sector amounting to EURO 36 million for 5 years.

Many Indian S&T institutions and universities have established long term cooperation agreements with quite a number of European scientific research institutions and universities, and there is now valuable information available from the rapidly increasing Indian global interaction in the all important area of academic publications. Data from internationally co-authored scientific papers in 1996 and 2003 lead to some interesting conclusions, which are noteworthy for furthering future Indian European cooperation in the creation of new scientific insights.[51] Major Indian scientists' collaboration in producing academic papers took place with the US, both in the mid-1990s and also in 2003. However, its share fell from 35 to 28% of all joint Indian publications. Co-authoring with the scientists of six major European scientists was strong, but also experienced a slight relative decline (33 to 30%). A more recent bibliometric analysis confirms the basic results, but includes a greater number of European countries, increasing their share to 51% of total joint publications of Indian scientists. The team examined co-publication in seven disciplines and found that almost no differences were noted in the order of the main cooperation partners, with the US coming in as No. 1 and Germany as No.2 between 2001-2005.[52]

While joint academic work with other emerging and developing countries is still significantly smaller, it is clear that the dominance of Western academic excellence will be increasingly challenged by the emerging nations, first and foremost from Asia. South-South (or in this case East-East) interactions and interchanges are not only advancing in trade of goods and services but are also accelerating in academia. The number of joint publications with Japanese, South Korean, and Chinese scientists rose from 6.5 to 15.2%, which was a significant (88%) increase from 1700 in 1996 to 3200 total joint publications in 2003. In addition, further diversification of Indian scien-

50 http://www.ec.europa.eu/research/iscp/pdfnew_delhi_communique_signed_eu.pdf; Austria, Bundesministerium für Wissenschaft und Forschung - BMWF (2007), Indienstrategie des BMWF, Status quo und Perspektiven der Kooperation mit Indien im Bereich Wissenschaft und Forschung. Vienna, BMWF.

51 Kirsten Bound (2007) India the Uneven Innovator. London: Demos, p.46.

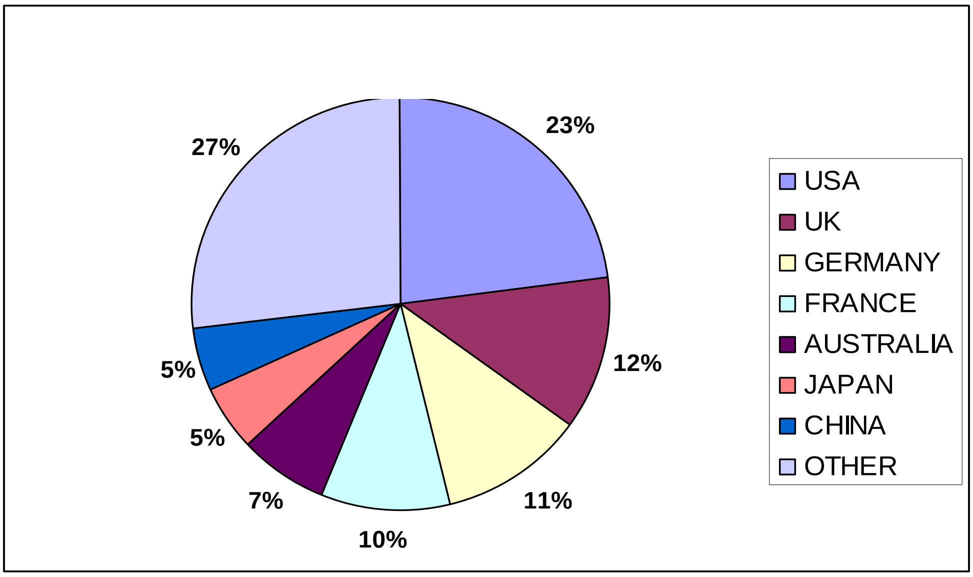
52 B. Mittermaier et al. (2007). Bibliometric Analysis on the Scientific Output of India. Bonn, BMBF.

tists' co-publication thrived, as the rise in joint publications with "other" countries from 22 to 26% demonstrates.

With more and more countries in the world aiming at creating knowledge-based economies, one way migration patterns so manifest in most of the second part of the 20th century have made way to what has been called brain circulation. That means competition for qualified scientists is intense. Graph 4 shows that the favourite destination of international students has been the US. Although it still got close to 25% in 2005, its predominance is challenged by the U.K., Germany, France, each of which got between 10 and 12%. Those three EU nations together, however top the US by about 10% points. Interestingly enough, China has been able to attract as many students from abroad as has Japan.

Students from India, China and South Korea provide the largest share of foreign students in the universities of Europe and the US. They have been contributing to those countries not only in economic terms, but with their preference of studying engineering and sciences, they have also enriched the advanced countries' R&D activities, which have been particularly pronounced in the case of the USA.[53] Statistics on 120000 Asian recipients of science and engineering doctorates granted by US universities between 1983 and 2003 show that three quarters of them came from China, India, Taiwan and Korea.[54] However, while the number of Indian doctorates was about equal to the graduates from Taiwan and Korea, it was only half of what the Chinese accomplished. This is altogether even more remarkable, since there are more Indian than Chinese students in America and that trend is expected to continue.

Graph 4: Destinations for international students



Source: N. Kumar, (2008) International Flow of Students.

One of the reasons why the East Asian are more active in pursuing graduate degrees in engineering and science is linked to most of them having a better educational base in science and mathematics, which shows up in the large number of first university degree in those fields. The ratio of those graduates as a percentage of the 24-old population was close to 10% in Taiwan and Korea and close to 2% and 1% in China and India respectively. Two further points are of interest. First, there was a significant increase of first university degrees in S&T world wide, reflecting the realization that the modern world will have more skilled technical and scientific personnel, able to start working or go on for graduate degrees. Secondly, besides the efforts of the East Asian nations, almost all European nations surpassed the US in accelerating their output share of engineer-

53 N. Kumar (2008). International Flow of Students. An Analysis related to China and India, Current Science, Vol. 94. No.1.

54 See: http://www.nsf. gov/statistics/seind06/c2//tt0-04htm

ing and science graduates. In short, European universities should not only be able to provide Master and PhD degrees in engineering and science, but also attempt to receive more students for first university degrees in those fields.

As to the study possibilities for "Western" students in the "East", China has been able to attract more students from the US than India. While most of the foreign students in these two countries come from neighbouring nations (Korea and Japan in China – Nepal and UAE in India), the US is No.3 in sending students to China and Germany and France Nos. 8 and 9. In India, the U.S. is only No. 10, with Germany and France sending even less students to India. That situation reflects first and foremost the fact that European students with a willingness to study abroad, will choose first to study either in another European country and/or the USA, but giving China's relative success, the lack of interest to attend Indian institutions may also have been caused by the paucity of good universities in India and the difficulty to be accepted in top academic institutions.

Similar data at European institutions of higher learning and their student population are not available, but it would seem likely that the pattern is similar, i.e. while inflows of students from India and China may be quite similar, graduation patterns are not and return flows are also clearly in China's favour. That is indeed an enormous challenge for the EU and India, and while available statistics will not provide indications of quality, both India and European authorities should focus on stimulating the inter-flows of students and researchers quickly.

The challenge has recently been taken up within the framework of the European Erasmus Mundi Program, which has provided scholarships for graduate studies towards a master's degree in fields as far away as medical sciences and technology on the one hand and communication and media on the other executed by a consortium of European universities working in tandem. In 2005, the European commission allocated EURO 50 million for the "India Window" leading to an increasing number of Indian students taking advantage of it. [55] While 500 students of a country with over 10 million students is a "drop in the bucket", it is a step in the right direction, and its outcome should be evaluated by the end of 2009, when the financial resources are expected to be fully distributed.

After having successfully coordinated an earlier European Higher Education Fair in New Delhi in 2006, a second is taking place in November of 2008, which brings over 100 recognized European Higher Education Institution from 27 European nations together with the help of the European University Association (EUA), the German Academic Exchange Services (DAAD) and the Netherlands Organization for International Cooperation in Higher Education (NUFFIC). It is apparent that India has become an interesting country for recruiting not only of engineers, scientists and researchers, but also students for undergraduate and graduate studies

5.3. Cooperation of major competitors

5.3.1. The United States of America

As a consequence of India's long standing political neutrality and its planned economy approach, which borrowed from the Soviet Russian model of economic development, official cooperation in the S&T field with the US were limited to a few technical assistance programs. This has changed over time, as more and more Indians, who had migrated to study and then work in the US made the Indian Government realize that the possible return or cooperation with those Nonresident Indians (NRIs) provided a base to bring innovation and technological progress back to India.

Inter-governmental relations also improved. As the first steps towards liberalization of the economy were undertaken, a 110 Million Rupee Fund was established to promote and finance S&T collaboration as well as educational and cultural exchanges between 1987 and 1998. Deeper collaboration was hampered by disagreements on India's IPRs regime, which was complicated by India's insistence to protect patented products but not processes, making it possible to continue

55 There were 133 students in 2005/06; over 400 in 2006/07 and over 500 in 2007/08; see: http://ec.europa.eu/education/programmes/mundus/index.en.html

with undertaking reverse engineering R&D in a number of industries, particularly critical in the pharmaceutical sector.

With India becoming a member of the WTO in 1995 and its adoption of a new patent law in 2005, those obstacles have been overcome, and US-Indian relations in the S&T field have accelerated. The Indo-US Science Technology Forum established in 2000 has identified areas of cooperation by sponsoring workshops, meetings, and scientific exchanges. An S&T Umbrella Agreement in 2005 has intensified the cooperation between scientists of the two countries in government, private sector and academia with special support for basic sciences, space, energy, health as well as IT and nanotechnology. That more intense cooperation between the public sector entities of the two countries has been driven by a number of facts, the most important of which was the realization in the US that the rapidly increasing Indian population in the engineering, IT and natural science field has become critical in a country in which those fields were less and less chosen by American born students.

It is then not surprising that private educational organizations, US universities, most of which are privately run, and foundations have increasingly be interacting with Indian counterparts. As discussed in the case of foreign investment's role in stimulating S&T development in India, the US TNCs and new Indian enterprises founded by young Indian scientists and engineers returning from the US are playing a critical role in the technological development of India's industry in general and the rapid progress of the IT sector in particular. While efforts to catch up with those important cooperation efforts cannot always be copied by the EU, especially since there are only few private institutions of higher learning with still relatively modest resources, it is clear that the coming EU FPs should consider to what extent they can stimulate those private induced cooperation activities, as well as possible public private partnerships in the S&T support programs.

In general, both the strong links between Indian students, researchers and engineers to the US and the renewed efforts of US universities to attract top talent will continue to provide a challenge for EU countries and their scientific community. Since the natural advantage, such as language, has played an important role in the choice of students, several faculties at more and more European universities are providing lectures and seminars in English. At the same time, a substantial number of EU universities are now also actively recruiting in India. While too early to say if all of these efforts will lead to a similar success as in the US, it would seem that the lessons are being learned rapidly.

5.3.2. Japan and China

Being less insistent on liberalizing India's economy than the US, the Japanese and Indian have longstanding relationships in the area of technological development. Besides, direct government-to-government support, which provided substantial foreign aid to India, Japanese industry has co-closely operated with a number of Indian industries, several of which are government enterprises. This has been particularly the case in the automobile and steel industry, in which the Japanese firms were the first to officially join Indian enterprises in the 1970s and with it introduced new technologies in sectors which were badly lacking behind the state of technology in the world.

Japan and India launched an eightfold initiative in 2007 to further strengthen cooperation in a number of areas, among which S&T plays a prominent part. It is planned to start a new Science and Technology Initiative, which will explore substantial cooperation in modern biology, biotechnology and health care, agriculture, hydrocarbon fuels, nanosciences and technology, environment, information and communication technology, robotics, as well as alternative sources of energy. In that context, the Governments of Japan and India will re-invigorate the Japan-India Joint Committee on Science and Technology Cooperation.

The Japanese and Indian Governments have also been active in supporting Asia wide S&T cooperation. A Trilateral Workshop for S&T Cooperation, organized by Ministry of Education, Culture, Sports, Science and Technology (MEXT) and the Japan Society for the Promotion of Science (JSPS), was held in March, 2007. That workshop came out of an earlier meeting and decision of a China-Japan-Korea Trilateral Ministerial Meeting on S&T Cooperation. The aim of the workshop was to explore trilateral joint R&D projects in the areas of environment and energy technology. About 30 researchers and administrators from the three countries discussed such specific issues as problematic and potentially harmful algae blooms in the East China Sea, membrane bioreactor R&D for sustainable water reuse, the impacts of anthropogenic aerosols on climate in Asia, air quality modelling, extracting resources from bio-waste, novel conservation processes for biomass utilization, and environmental management technology for sustainable utilization of environmental resources.

Bilateral cooperation between India and China has been rare during most of the last 50 years, as both countries saw each other as competitor rather than a potential partner. In addition, the border conflict in the early 1960s made scientific cooperation even less desirable. Some collaboration occurred, but mainly through multilateral channels with several other developed and developing countries together. Similar to other initiatives to open up India's economy, the two countries formally agreed to cooperate in S&T in 1988, but while researchers expected their bilateral contacts to take off, the scope and scale of research cooperation remained low. Collaborative work remained limited, concentrating on physics and clinical medicine.

Bilateral relations were strengthened, when Chinese Prime Minister Zhu Rongji visited India in 2002. Both countries signed a memorandum of understanding (MoU) on S&T, space cooperation and hydrological data sharing. Examples of the renewed cooperation, was the MOU signed by Indian Space Research Organisation (ISRO) and the Chinese National Space Administration also in the peaceful uses of outer space. The relations were further developed with the visit of China's president, Hu Jintao in 2006, who was proposing a 'ten pronged strategy' to boost cooperation. Both sides agreed to launch joint research projects into earthquake engineering, climate change and weather forecasting, as well as in the fields of nanotechnology and biotechnology.

Both countries have realized that they have complementary science and technology strengths. For example, in genomics research, there are plans to use India's excellent software and human resources to analyze the large amount of experimental data being generated from high-throughput Chinese labs. New collaborations are going beyond the interests of the two countries, and generating science that is relevant across the globe. For almost two years, India's Council of Scientific and Industrial Research and the National Natural Science Foundation of China have worked together investigating changing environments, ocean variability, land ecosystems, land-ocean interactions, land-atmosphere interactions, ocean-atmosphere interactions and coupled modelling. One of those programs is the Monsoon Asia Integrated Regional Study (MAIRS) - a new international global change program of the Earth System Science Partnership, which is proposing joint investigations into the global change and monsoon-driven processes that affect countries of the Asia-Pacific region.

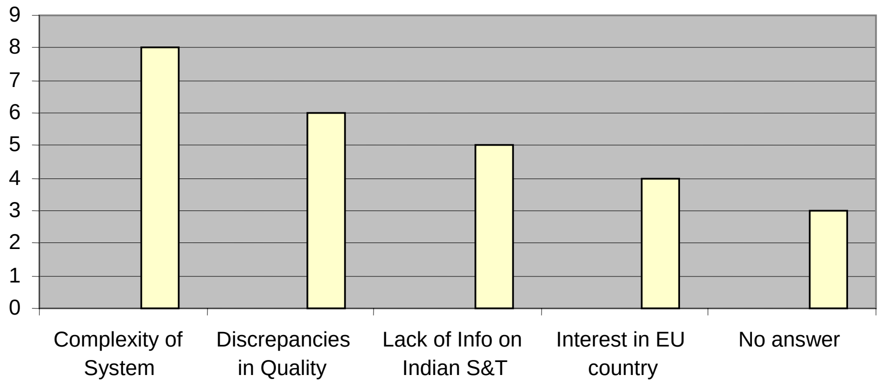
6. Lessons to be learnt from S&T cooperation with India

The cooperation of major European countries in the S&T field has been long lasting, but has gone through some dramatic changes, which have been generated by India's move towards opening up the economy and reforms of its major institutions of learning and research and the more rapid exchange taking place with competitor countries from Asia and the Americas. It was not too early that the EU recognized the need to bundle its resources and plan a common approach in the S&T field towards such large and diverse countries like India, China, Brazil and Russia.

While the increasing joint research projects and academic interchanges between India and the EU countries prove that there has been a real take-off in this field, the above mentioned comparative statistics indicate that those efforts are still behind the ones undertaken in the other large emerging economies. The results of the 2008 surveys by the CREST Working Group give only a few hints of what the major reasons for the somewhat slower developments are and what are considered to be the major challenges of S&T cooperation in the future.

As Graph 6 shows on top of the list of those challenges are the complexity and lack of transparency of the S&T system. Moreover, the search for finding high quality R&D partners and top students is made difficult not only by the fact that those qualities still seem to be in short supply in India, but also because of the above mentioned fragmentation and bureaucratization of the public S&T system.[56] While the complexity of the Indian S&T will not disappear in the near future, the joint European approach with the multi-year framework programs should prove helpful to identify and cooperate with those organizations and academic institutions which will lead to results. In order to do so, the evaluation of the joint efforts of the FP5 and FP6 are a must.

Graph 5: Challenges of S&T cooperation with India



Source: CREST Working Group "Internationalisation of R&D", number of responses to questionnaire on EU countries' S&T cooperation with India (several countries gave multiple responses)

For the small EU member states the challenges are threefold: it is first to raise interest within the scientific community of their own countries about the possibilities of doing R&D with India's counterparts; for that to happen, they need secondly to overcome the lack of information to identify and prepare exchanges in the S&T field. Finally, it is important to find a niche in a subcontinent of which even the smallest state is often larger than the majority of the EU members. Here, the joint EU approach underway should prove of help. One recent example of great value to the smaller countries should be the CREST Working Group Input Paper on "Recommendations on joint approaches to gain process relevant information on the S&T situation in cooperation with third countries."

It is interesting to note that the EU-India cooperation is neither characterized by the disillusion nor the disappointments expressed in the case of China, but by rather positive feelings towards S&T cooperation with India. Among others, one of the major challenges, namely the lack of observing internationally accepted IPRs rules, is only mentioned once in India's case, although it has been pointed out above that implementation of the 2005 legislation on IPRs is not yet fully functioning. One major reason for that omission would seem to be the fact that current European-Indian cooperation in the S&T field is concentrating on public sector academic oriented R&D and scientists exchanges, with yet a somewhat less emphasis on the applied and innovation part in the S&T field.

6.1. Lessons from international movements of Indian students and researchers

By now it has become clear to the EU community that the demographics and choices of many European students to concentrate on business, law and arts rather than natural sciences and engineering will require an active human resource policy with countries like India and China, where there is a much larger reservoir of potentially skilled engineering and science students. In India,

[56] During an India-EU Workshop in early 2008, it was pointed out that India was slow in implementing the joint S&T projects and a search was started to examine the major causes and get on top of the potential problems. The Financial Express, 3-10-2008.

further strong increases of students and researchers in those areas can be expected, which should lead beyond mutually beneficial cooperation in the research area and could focus on academic and scientific programs for undergraduate, graduate and post graduate students in science and engineering.

The American experience with Indian students and young researchers in the science and engineering indicates not only led to positive impacts those immigrants have had on the US economy, but have increasingly an additional impact on the Indian economy too. There are first the simple income and employment effects foreign students have provided not only in the US but also in the UK. More importantly, there is an impact on keeping at the frontier of science, which would have not been possible in the US without an increasing number of young, disciplined and well trained researchers and teachers, which indeed did turn out to be the case not only with Indians, but also with most other Asian students and researchers working in American universities and research laboratories of public and private institutions and firms.

While English academic institutions have not experienced the growth of Indian student migration compared to the US (ca. 80000 students in 2008), they are still leading in Europe (12000 students vs. 4000 of second ranked Germany). It is also clear to them that competition has increased from all over the world. Besides the US, there are strong English speaking curricula in Australia, Canada, and Nee Zealand, governments and academic institutions which have been actively engaged in attracting Indian students. Continental Europe has had a more difficult stand despite individual countries' efforts to lure good Indian students and researchers.

Many universities in non English speaking countries of the EU are offering today courses in English, and they have the additional advantage to charge much lower fees for most university courses than the American and English institutions. Nevertheless, curricula are only now being harmonized and adjust to an international system of degrees and their pre-requisites. More importantly, many foreign students find out that after graduation or after getting a higher degree, there are difficulties entering the job market. This issue has also now been addressed, since it became obvious that the net benefit of high quality engineering or science for the European economy should be substantial. However, governments which are now engaging in very ambitious programs to attract capable Indian students and researchers will have to do their cost-benefit analysis to justify those expenditures to the tax payer.

6.2. Enhanced EU-India S&T cooperation: Old and new lessons

Academic cooperation and exchanges between India and Europe have been supported in one way or another for a long time, but the emphasis with which individual European governments and the EU as a whole are pursuing it now is unprecedented. That, of course, raises new opportunities and challenges. Since the EU-India cooperation is first and foremost about government-to-government interchanges, it would seem appropriate to point out that this is only one facet of the overall objective of S&T cooperation in a globalised economy. Furthering S&T is not final goal in itself, but the idea is to pursue and create innovation in many fields, the new value added of which should help all partners involved in the partnership. As a consequence, it should be remembered that crucial parts of the innovation process requires private initiative, for which governments can provide incentives but they cannot enforce.

It is then crucial to have a further look into the interaction between mostly public universities and public R&D institutions on the one side and innovative enterprises on the other. As discussed, both in the India's S&T policy section as well as in the section dealing with the approach the EU has taken in S&T cooperation, the recent establishment of the European Business and Technology Centre (EBTC) is expected to provide a platform for profitable interactions between EU and Indian business and research institutions to enhance mutual trade and research partnerships. It remains to be seen to what extent that institution will be able to provide a further push to link science with industry. External support like the SPREAD Program have shown the benefits to be derived from those linkages, but that process needs a number of intermediaries, which governments tend to forget or neglect. However, several Indian research institutes (especially from

CSIR) have undertaken those steps and have become successful in bridging the gap. Those efforts are still a small part in the vast research area in a country like India. With the EBTC the EU should help to strengthen those connections, leading to improved coordination and a broader impact of S&T on the Indian economy.

The rapid succession of the EU framework programs, and in India's case the rapid rise of resources allocated to them, have had little chance to look back and evaluate the accomplishments and failures of the past. The large and sometimes growing gap between the R&D and its application at the frontier of science and technology and the need in India to have an increasing amount of firms and people absorb and apply already known technology is evident. While both the Indian government and a number of external programs do concentrate on that aspect, it would seem that too much focus is still put on frontier technology and institutions without asking about its applicability.

Last, but not least, when discussing S&T development with Indian counterparts, the issue of financial inputs is of course of utmost importance to get the program or project started. However, outcomes and impacts have to be considered early in the process to be able to monitor progress and - if necessary - stop a program if early signs show disappointing results. As a consequence, the EU will have to build in those safeguards, as they proceed to expand their S&T cooperation with Indian authorities and institutions.

6.3. Lessons from supporting private investment in S&T

As shown above, India's private sector has increasingly started to invest in R&D. Those investments were undertaken by relatively large enterprises in some leading industries. No external or government support is necessary, except an incentive system which does not stifle those activities through excess taxation and administrative restrictions. The case is even clearer for the R&D investment by the TNCs in India. Again, the Government of India has provided incentives and also made efforts to improve the infrastructure.

For the last ten to fifteen years the Government has also supported a significant number of newcomers and small "scientific" enterprises to get access to new or known technology and improve on it and have it apply to new processes and products in India (see Box 3 in the Annex). In some cases, as this has occurred in life sciences, public-private partnerships have been formed. In those cases, it would be appropriate indeed for the EU to support endeavours, after having examined the potential for useful involvement of European and Indian R&D institutions. To what extent those support schemes would fall under S&T programs or be part of SME support would have to be clarified so that overlapping responsibilities are minimized.

In view of the fact that India's innovation policies have neglected somewhat in favour of going for frontier tech, it may be useful to discuss exactly those S&T programs which would have some impact on commercial use and applied areas. As explained in the Annex, there are number of programs to support the technological development of young "technopreneurs." While the majority is concentrating on home grown technologies, several ones are also engaged in applying their own S&T efforts. That support could either be given jointly with an Indian government agency .or through a financial intermediary, active in venture capital and technology development financing, but would have to include young European counterparts researching and applying their findings in the same area of expertise.

6.4. Conclusions: Alternative scenarios of India's future S&T approach and consequences for cooperation policies

The possible danger of China retreating into techno-nationalism and protectionism has been noted earlier. It is not inconceivable that this may also happen in India, a country in which the majority of people have not yet been able to participate in the fruits of the country's recent rapid development and the electorate of which is willing and able to throw out any government not paying attention to the problems of "the huddled masses." Before evaluating possible scenarios, it may be useful to summarize the major strengths and weaknesses of the Indian economic, social and political environment and their relevance for S&T policy.

Starting with the strong points, there is little doubt that while democracy is not a guarantor for wise political decision making, it is – in the words of Winston Churchill– the least worse. The country has come a long way from planning and excessive regulation to find a more flexible system in which individuals can make decisions more freely in most activities, while keeping a guiding hand and government supervision on a good part of them. The development of an increasing number of S&T institutions towards flexibility and efficiency and away from hierarchy and bureaucracy is likewise encouraging.

India's young working age population is large and rapidly increasing. It is estimated that the 20 to 24 year old cohort will reach 100 million by 2010, twice as much as the young people of same age in the US and Western Europe combined.[57] If the educational system can catch up with demands of that group, the results could be formidable. Already today, India's young and large population is considered an asset by all its partners, as it has proven to be of extraordinary value to an increasing number of high tech global companies and whole economic regions. In addition, it has increasingly had an impact on the domestic economy, both as entrepreneurs and skilled employees in the country, but also as networking community of more than 20 million Indians around the world.

The age of information technology has been met by India like no other developing nation in the world, and its trials and triumphs have been recorded everywhere, changing opinions of the world towards India and the view India has about itself, realizing that the days of the Hindu rate of growth are over. The remarkable path from providing low cost call centre assistance to sophisticated software developer has resulted in attracting all major global players in that field to invest in India. More importantly, it has shown direct effects on the average Indian's life by making cheap communication possible for an increasing number of particularly young Indians.

Last, but not least, India is searching for and creating possibilities to combine traditional knowledge in fields of biology and medicines with path breaking research at the frontier of life sciences. In that context it has started an ambitious $2million project, called the Traditional Digital Library, which will record the country's traditional medicines in five languages (English, French, German, Japanese, and Spanish) in an effort to stop people in advanced countries claiming them as their own and patenting them.

Where there is lots of light, there are also mighty shadows, which start with governance problems in a subcontinent which is known for religious fervour and violent outbreaks at home and uneasy relationships with its neighbours. In addition to territorial disputes which have been lingering since Independence and have brought fears of an atomic war with its neighbour Pakistan more than once, conflict with China proceeded for a prolonged period of time and led to loss of Indian territory.

As stated above, India's youthful population is its most important asset, but while educational facilities have multiplied in the last few decades, quality of education has not. Besides the dearth of top quality universities, India has not yet been able to build up a reliable primary and secondary education system, on which finally a good tertiary system has to be based on.

In the S&T field compartmentalization continues to be strong. That separation is visible between educational institutions and research outfits as well between public R&D labs and company R&D. Added to that are the remnants of what is commonly known as the "License Raj", i.e. continued red tape, ranging from controlling wage scales in laboratories to rules of making procurement of equipment difficult and cumbersome. That is also true for doing business in India, no matter what size or age the firms are. The recent rankings of how good or bad that situation is in comparison with the rest of the world shows some unsettling results. In a number of indicators which are all centring around the simple way of having firms cope with their day-by-day environment, India

57 National Science Foundation, Science and Engineering Indicators 2004. http://www.nsf.gov/statistics/seind04/c2fig02-32.htm.

comes in as No. 134, below a number of African and less than stable mid-eastern states.[58] Similarly, Transparency International registered India as one of the top players in the Business Bribe Index, and in the Corruption Perception Index, it received only 3.5 points out of 10 for perfect transparency.[59]

Given those assets and liabilities it is now useful to construct a matrix of possible outcomes which should have some relevance for India's S&T system and its partners' engagement in that area. Four different scenarios are considered, although it should be made clear from the beginning that none of them will probably be chosen exclusively by the Indian policy makers in the years to come. There is first the ambition to become one of the global science leaders, which requires not only the rapid build-up of super skills producing Indian IP products and services but also by further strong steps towards liberalization and adjustment to globalization. On the opposite site, there is that remote but not impossible threat of going it alone and strengthen public sector institutional mission based science on a strictly national scale.

More likely are the other alternatives, where - in scenario 3 - India equally continues with the strong opening of the economy but concentrates on IT sector for both employment and income generation and to a lesser extent on areas where excellence has been achieved without trying to be at the frontier in global R&D. Finally, considering its need to lessen poverty and supporting the large number of small and medium sized enterprise in their aim to modernize, India could opt for an "appropriate" technology strategy, i.e., mainly adopt and diffuse known technologies, part of which the country hopes to develop itself and other parts which it may adopt from abroad.

Following the discussion of the Governments plans and policies, it would seem reasonable to assume that India would like to reap the benefits from combining alternatives 1 and 4, which would mean that ideally, policy makers would like to pursue a two pronged approach by moving as quickly as possible to the frontier of S&T development at the same time move the backward sectors forward by having them introduced to known technologies.[60]

58 World Bank Group (2008) Doing Business in 2008. Washington, The World Bank.

59 See: http:www.transparency.org/policy_research/surveys….2007/cpi/surveys_indices.

60 See: Comparative Summary Report and Summary of Recommendations on the cooperation with Brazil, India and Russia, CREST OMC Working Group on Internationalisation of S&T, Brussels, December 15, 2008

7. Recommendations for enhancing S&T cooperation with India

Based on the present analytical report, supported by the analysis of the questionnaires of the status of the bilateral cooperation between Member States/Associated Countries and India and on the conclusions of the OMC-Working Groups´ discussion, this section provides recommendations addressed to the EU Member States/Associated Countries and the European Commission in order to have them strengthen S&T cooperation with India and increase the respective impact.

The first part of the recommendations is generic in character and closely corresponds to the recommendations on S&T cooperation with other priority partner countries.

The second part of the recommendations summarizes specific recommendations concerning European S&T cooperation with India.

7.1. Recommendations targeting at S&T cooperation with India and other priority partner countries

Fostering a knowledge-based strategic agenda-setting

It is recommended to:

- deepen the knowledge-based dialogue between the EU Member States and Associated Countries based on the realisation of increasing mutual benefits from S&T cooperation with India as a strategic partner of the EU. The knowledge base could be strengthened by
  - the outcome of further mutual learning exercises,
  - systematic information gathering on Indian S&T including policies through ERAWATCH and pooling MS´/AC´ efforts,
  - (joint) efforts of the MS´/AC´ and Community Science Councillors,
  - deliverables of relevant EU funded Coordination and Support Activities,
  - impact assessment of bilateral S&T agreements at MS´/AC´ and Community level.
- complement the ongoing S&T dialogue between the European Commission and India with an S&T dialogue between the EU MS (and possibly AC) and India, following the high-level strategic forum on EU-India S&T cooperation in February 2007. In view of the Communication of the European Commission on international S&T cooperation [61] and following the respective Council Conclusions of 2 December 2008 [62] such a dialogue should aim at identifying joint interest beyond the themes of the EU RTD Framework Programme and at fostering coordination of concrete implementation measures building on MS´ (and AC´) instruments.
- make regular use and ensure a proper dissemination of results of completed or ongoing EC-funded coordination and support projects targeting India [63] in order to improve S&T cooperation with India, building on information which
  - address the Indian S&T landscape, key institutions, existing, cooperation patterns as well as barriers for the cooperation,
  - draw conclusions on cooperation potentials and ways to further enrich cooperation.

  These data could provide a valuable input to political dialogue at MS´/AC´ and Community level, could add new momentum to the implementation of S&T cooperation and should prepare the ground for strategic scheduling future Coordination & Support Activities of the EC.

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61 Communication from the Commission to the Council and the European Parliament. A Strategic European Framework for International Science and Technology Cooperation, COM(2008) 588, Brussels, 24.09.2008.

62 Conclusions of the European Competitiveness Council concerning a European Partnership for International Scientific and Technological Cooperation, Brussels, 02.12.2008.

63 AOUDA, New Indigo, EUINEC etc.

Offering an optimum framework for S&T cooperation and removing barriers

It is recommended to:

- examine how well known existing good practices in funding schemes can be implemented at the individual EU country as well as the Community EU level for joint S&T of MS´/AC´ with India and introduce advanced schemes where gaps are found on MS´/AC´ and Community level, aiming wherever possible at reciprocity. This could be done through
  - pooling experiences of MS/AC and from Community activities, taken into consideration the deliverables of relevant completed and ongoing coordination and support projects,
  - analysing funding schemes as regards driving motivations, strategic orientations, research priorities, rules and regulations, evaluation practices, budgets and legal implications, as well as corresponding restrictions and developing scenarios to overcome these barriers,
  - promoting the integration of Indian program owners in thematic ERA-NETs.

- move towards a more flexible, simplified and harmonized cooperation framework through Community S&T agreements in order to overcome present barriers through
  - making sure intellectual property rights as stipulated in India's laws are implemented,
  - allowing easy transfer of S&T equipment (donations) to India without custom fees, easy trans-border shipping of scientific material , and open access to S&T infrastructure in India,
  - permitting tax free allocation of S&T funding from EU program owners to Indian institutions,
  - offering simple administrative procedures for EU S&T organisations to establish representations in India, including the provision of working visas for EU personnel.

- stimulate an open but coordinated dialogue between European and Indian public and private S&T and innovation stakeholders on themes relevant for the framework of S&T cooperation, ranging from a full mutual understanding of each others IPR rules and regulations to joint participation in tri- or multipartite R&D undertakings. For implementing such dialogue schemes ongoing and upcoming coordination and support activities funded under the Specific "Capacities" Programme within the RTD Framework Programme should be applied.

Putting emphasis on the "human dimension" through brain-circulation

It is recommended to:

- increase brain-circulation between the EU and India through promoting the opportunities, advancing funding schemes and removing still existing barriers. New concepts should be developed on national, bilateral and Community level for enhancing outward mobility of researchers from EU-MS/AC towards India, which could include
  - promote Indian teaching and research infrastructure in order to better attract EU researchers,
  - foster the creation of national scientific personnel mobility centres in India and their involvement in the ERA-MORE network of European mobility centres,
  - make use of the EURAXESS Portal (building on the examples for Australia, Canada, Chile and Japan).

  Following examples of good practice, MS´/AC´ should consider offering return - fellowships for high-qualified Indian scientists in order to pave the way for sustainable cooperation. Along that line the temporary funding of joint research groups consisting of young Indian and EU talents could be considered by MS/AC. At Community level the introduction of return fellowships for Indian scientists as a new component of the Marie-Curie programme should be seriously considered.

- attract the interest of Indian students and researchers who are supported through European fellowship programmes at national or Community level to work in Indian branches of European industries. Dedicated promotion campaigns could be foreseen by MS´/AC´ programme owners and by the European Commission. It should be envisaged by the respective programme owners to establish a European alumni-database to map the flow of Indian students and researchers to stay in touch.

- analyse the impact of the European Visa Directive in order to prepare the ground for a better access of Indian scientists to the European Research Area.

7.2. Specific recommendations targeted at S&T cooperation with India

Strengthening brainpower attraction and circulation

It is recommended to:

- increase the promotion of EU programmes at Community (Erasmus Mundus, Marie Curie) and MS´/AC´ level dedicated to bringing more Indian students and researchers to European institutions in order to benefit from India's emerging advantage in the manpower field.
- start at undergraduate level and attract India's large number of well qualified high school graduates, who have difficulties in being accepted at the few Indian top institutions.
- promote Public-Private Partnerships for the establishment of European institutions of higher learning and educating young scientists in India at European standards.

Enhancing strategic S&T cooperation and advancing the instruments and institutions

It is recommended to:

- strengthen the links of MS/AC´ institutions to applied scientific institutional stakeholders of India's innovation community such as the Council for Scientific Industrial Research (CSIR) to develop a common framework i.e. through joint innovation programmes. Wherever appropriate, coordinated activities of the MS/AC should be considered in order to allow a better trans-European networking of innovation stakeholders.
- analyse options on MS/AC level of joint EU-India efforts to transferring science to innovation and to strengthen joint industry oriented research among others through - facilitate links between academic research and commercial utilisation through financial intermediaries. In that context the European Commission should examine in which way the European Investment Bank jointly with Indian financial institutions could also support those efforts,
  - the European Business and Technology Centre (EBTC) which was opened in October 2008 in India and is expected to provide a platform for profitable interactions between EU and Indian business and research institutions to enhance partnerships,
  - setting-up a joint EU-India task-force on industry oriented research with participation of industries from both sides.
- set-up at Community level a joint group of high level European and Indian scientists with expertise in priority areas to analyse the outcome and the scientific, economic and societal impact of previous EU-Indian S&T cooperation in order to provide strategic experts´ guidance for future directions on topics and most appropriate formats of S&T cooperation. In particular in the rather extended area of environmental sciences could be addressed. Here, it seems crucial to put the S&T cooperation into a wider policy framework and foresee a trans-sector policy coordination within EU-India's overall partnership. Wherever appropriate and respecting the principle of variable geometries, MS and AC should be invited to coordinate there national or bilateral activities towards/with India to contribute to the implementation of the strategic EU-India partnership.

8. Annex

Box 1: Restructuring public R&D institutions to foster innovation in Indian industry

The Case of CSIR

Founded in 1942 and becoming an independent institution under the Prime Minister's Office in 1947, the Council of Scientific and Industrial research (CSIR) had to fulfil a variety of functions, ranging from the scientific study of problems affecting industry and trade and the dissemination of information with regard to research concerning industrial matters to the utilization of research results for the development of industries in India.

It turned out that the latter function, so crucial in the innovation process of industry, was lagging badly behind more academic concerns of the Brahman scientists to write papers and participate in conferences. Whatever concern there was for applied research and its use in Indian industry focused on known processes for medium and small firms, many of which were not able to connect with the institutes in fruitful endeavours. Rather to look for technology, which seemed to reinvent the wheel, the large industrial firms tried to obtain foreign exchange with which they could buy technology from abroad.

As part of the first liberalization attempts of the Rajiv Gandhi Government, the 1986 Abid Hussain Commission Report on Public R&D Institutions examined those issues and recommended a host of reform measures to make the CSIR institutes more effective and relevant to industry. Among them was the requirement to earn an increasing share of their expenditures through revenues received from firms through licenses or other collaborations. Jointly with a gradual macro-economic policy shift towards openness and competition, which was increasingly required to escape foreign exchange crises, and the IT revolution making information more widely and quickly available to all industrial firms, CSIR started with a restructuring process, which has continued to show results during the early years of the 21st century.

With CSIR labs being given autonomy in operations based on their own commitments and the delivered outputs and their capacity to earn income, the transformation from a large and unwieldy bureaucratic outfit to a more streamlined and diversified group of institutes is reflected in less but more dedicated scientists worker in a smaller number of institutes, now rapidly increasing patent filings both within and outside the country, publishing relevant scientific articles, and linking up with industrial firms, especially in sectors in which India is emerging as major innovator and exporter of industrial products.

Publication of scientific articles in internationally renowned journals nearly doubled from 1575 to 2900 between 1995 and 2005. Patent filings have taken off from 264 to 419 in India during the last decade and they have even risen faster abroad from less than 100 to close to 500, with earlier years even topping those numbers. By 2005 over 1200 patents were in force under prosecution, and nearly 3000 pending prosecution. With respect to foreign patents the numbers reached close to 1000 and the pending patents had passed 2000.

Income from outside activities has been raised from IPR 1.8 bill. to 3.1 bill. (the equivalent US$ 65 mill) in the last 10 years. With government support doubling at the same time and reaching the equivalent of $325 mill, the CSIR institutes are currently earning roughly 20% of their expenditures by being able to sell their services and expertise. Realizing the potential benefit and incentive to go out and connect with industry, a number of laboratories are planning to double their share of earnings in the coming years.

Box 2: Financial intermediation for S&T development and innovative enterprises

The Industrial Credit and Investment Corporation of India (ICICI) was formed in 1955 at the initiative of the World Bank, the Government of India, two foreign banks and representatives of Indian industry. The principal objective was to create a development financial institution for providing medium-term and long-term project financing for Indian industries. Contrary to the already existing wholly government owned Industrial Development Bank, ICICI pursued a unique style of combining public service with entrepreneurial élan from the beginning. Its management and well qualified staff introduced a number of innovative programs, which provided technical assistance with long tem finance for new exporting industrial enterprises as well as venture capital in the context of a technological development operation.

ICICI is the responsible institution providing finance to one of the earliest collaborative schemes in fostering innovation: The Sponsored Research and Development (SPREAD) Program, in which a number of the more dynamic laboratories collaborate with industry to convert ideas, designs and prototypes of processes and products into viable commercial outputs. The scheme provides financial support to SMEs to fund projects which have been developed by research institutes in general and the CSIR laboratories in particular, with the proviso that should the project fail, the firm would not have to repay the loan. In case of success, it was stipulated to return the loan plus a small amount of the profits achieved through the new project. Since 1994 SPREAD has funded 120 projects. Out of the 46 which were completed by 2006, 68% were successful in being commercialized. By mid-2007, 21 projects were under implementation, which also included the first ones of the follow-up project SPREAD R.

Beyond ICICI's intermediary role in the SPREAD, the 1998 WB Technology Development Project also helped in establishing a number of venture capital funds, both with ICIC and some other state supported companies (SIDBI, APIDC and GVFL), which have been active in stimulating industrial innovation at various stages of product and process development. While ICICI Venture followed more the pattern of a typical venture capital company, preferring firms having passed the early development stage, the state owned smaller companies have been undertaking mostly early-stage funding.

In addition, jointly with the State Government of Andra Pradesch ICICI launched the ICICI Knowledge Park, which was established close to the city of Hyderabad in 2000, providing and leasing a large area of built up laboratory and office space for research and development in all knowledge intensive fields with focus on pharmaceuticals technology, biotechnology and specialty chemicals. It is equipped with a virtual information centre, which connects the tenant companies with a number of important research and academic Indian and foreign institutions. Other activities planned and/or initiated in 2007 include enterprise creation through the leasing of incubators, preparation of firms' business plans, as well as assistance in marketing and getting access to venture capital. Beyond that, management is launching a seed fund for life science entrepreneurs and opening a laboratory for research on neglected diseases.

Box 3: Indian S&T support programs for SMEs and young entrepreneurs graduating from universities

Technology Development and Demonstration Programme (TDDP): This programme was initiated by the Department of Scientific and Industrial Research (DSIR) with the aim to catalyze and support activities relating to technology absorption, adaptation and demonstration including capital goods development by involving industry and R&D organizations. Under the programme, innovative technologies are up-scaled from the "proof of concept stage" to "pilot plant/pre-commercial stage" by the industry. The projects involve research, design, development and engineering and are executed by industry and are overseen by experts from universities/laboratories. DSIR has supported over 150 projects so far since the implementation of the scheme in 1992. More than 65 projects have been completed and 31 companies have started paying lump sum royalties. So far, more than Rs. 35 million royalties have been made. About 15 patents have been filed based on projects supported under the scheme.

New Millennium India Technology Leadership Initiative (NMITLI): The government of launched a new initiative during 2000 to enable Indian industry to attain a global leadership position in a few selected niche areas by leveraging innovation-oriented scientific and technological developments in different disciplines. In a very short period of time, NMITLI has crafted 25 technology projects involving approx. 50 industry partners and 150 R&D institutions with an estimated outlay of US$ 37 million (RS. 1.600 million). The funded projects belong to technological areas such as nano material catalysts, industrial chemicals, gene-based new targets for advanced drug delivery systems, bio-technology, bio-informatics, low-cost office computers, etc. The scheme is being implemented by the Council of Scientific & Industrial Research (CSIR).

Small-scale industries continue to contribute significantly to employment and output industrial production of India. Earlier programs have been intensified with special emphasis on modernization and technology support. The best known of the multiple efforts are the Integrated Technology Upgrading and Management Programme (UPTECH), the Home-grown Technology Programme and the Technopreneur Promotion Programme. They have been sponsored by The Office of the Development Commissioner (small-scale industries), TIFAC, and DSIR.

The *Integrated Technology Upgrading and Management Programme* was founded in 1998 and was renamed later the Small Industry Cluster Development Programme. The scheme applies to any cluster of industries where there is a commonality in the method of production, quality control and testing, energy conservation, pollution control, etc. among the units of the cluster. The scheme aims to take care of the modernization and the technological needs of the cluster. It covers a comprehensive range of issues related to technology upgrading, improvement of productivity, product diversification and their marketing, as well as special training needs of the cluster enterprises. While successful in some cases, no evaluation has been made to judge if a continuation is warranted.

The *Home Grown Technology Programme* (HGT) has been created by TIFAC for supporting the commercialization of technologies developed by indigenous R&D activities. The HGT programme, which started in 1993, promotes Indian capabilities for development of contemporary & novel products and processes. In the process, it catalyses research and development efforts in the country and fosters closer linkages between R&D/technology institutions and industry. Hence, it was started primarily to support the Indian industry for achieving competitive strengths through technological innovation. The HGT programme assists industries/companies for scaling up laboratory/bench scale technology to pilot or pre-commercial stage. The programme provides soft loans (generally not exceeding 50% of the project costs) for technology development which is repayable in user friendly instalments after the completion of the projects. In addition, the HGT programme provides techno-managerial support. More than 60 projects have been supported so far, with some of them still awaiting implementation.

Technopreneur Promotion Programme (TePP): In 1998-1999, the Ministry of Science and Technology launched the TePP to tap the vast innovative potential of Indian citizens. The programme is jointly operated by the DSIR and TIFAC and aims to support individual innovators working within the informal as well as formal knowledge system so as to enable them to become technology-based entrepreneurs (technopreneurs). TePP provides financial support to individual innovators to convert an original idea/invention/know-how into a working prototype/process. Under the programme, any Indian citizen, technician, engineer, scientist, etc. having an innovative idea can be supported. The proposal can be submitted either by an individual on his own or jointly with the sponsoring organization involved in the technology development and promotion. Proposals from the young entrepreneurs are considered for TePP support, if the annual turnover of the company does not exceed Rs 3,0 million. Since its inception, the Government of India under the TePP programme has given financial support to over 115 projects. Out of these, around 50 projects have been completed and around 25 projects have been commercialized. The scheme has resulted in grants of domestic patents to more than 10 innovators and US patents to 3 innovators, besides the commercialization of the processes.

Table 4: Foreign Direct Investments (FDI) in 1999 and 2006

	Inward FDI flow (Millions of US $)		**Outward FDI flow (Millions of US dollars)**	
Region/economy	**1999**	**2006**	**1999**	**2006**
World	1 098 896	1 305 852	1 108 354	1 215 789
Developed economies	860 151	857 499	1 037 379	1 022 711
Europe	521 230	566 389	766 336	668 698
European Union - 25	502 636	530 976	727 104	572 440
France	46 545	81 076	126 854	115 036
Germany	56 077	42 870	108 692	79 427
Ireland	18 211	12 811	6 109	22 101
Italy	6 911	39 159	6 722	42 035
Netherlands	41 205	4 371	57 610	22 692
Sweden	60 961	27 231	21 927	24 600
UK	87 979	139 543	201 451	79 457
United States	283 376	175 394	209 391	216 614
Japan	12 741	- 6 506	22 743	50 266
Australia	3 269	24 022	- 421	22 347
Africa	12 404	35 544	2 642	8 186
South America	69 677	45 019	7 101	36 720
Central America	16 157	24 364	2 489	6 960
China	40 319	69 468	1 774	16 130
Hong Kong, China	24 578	42 892	19 369	43 459
India	2 168	16 881	80	9 676
Singapore	16 578	24 207	8 002	8 626
Russian Federation	3 309	28 732	2 208	17 979

Note: Time series only separate from 2002 on

Source: UNCTAD (2007) Major FDI Indicators,
http://stats.unctad.org/FDI/TableViewer/tableView.aspx?ReportId=899

Tables and Figures

Figures

Graphs

Boxes