Technology and
Innovation Management

WORKING PAPER

India's National Innovation System: Key Elements and Corporate Perspectives

Cornelius Herstatt
Rajnish Tiwari
Dieter Ernst
Stephan Buse

January 2008 / Working Paper No. 51
(Revised edition April 2008)

This Working Paper has been prepared as a project report for the project "India's Innovation System: Exploring the Strengths" carried out in cooperation with Honolulu-based East-West Center

Hamburg University of Technology

Schwarzenbergstr. 95, D-21073 Hamburg, Germany

Tel.: +49 (0)40 42878-3777; Fax: +49 (0)40 42878-2867

www.tu-harburg.de/tim **www.global-innovation.net**

India's National Innovation System:
Key Elements and Corporate Perspectives

Working Paper / Project Report

By

Cornelius Herstatt, Rajnish Tiwari, Dieter Ernst and Stephan Buse

Research Project Global Innovation
Institute of Technology and Innovation Management
Hamburg University of Technology
Schwarzenbergstrasse 95
21073 Hamburg, Germany

Tel: +49 – (0)40 – 42878 – 3776
Fax: +49 – (0)40 – 42878 – 2867

www.global-innovation.net / www.tuhh.de/tim

Project Report prepared for the project

"India's Innovation System: Exploring the Strengths"

A project of the Institute of Technology and Innovation Management (TIM), TUHH
conducted in collaboration with the East West Center, Hawaii

Project supervision: Prof. Cornelius Herstatt
Project lead: Rajnish Tiwari

Together with Dr. Stephan Buse, Assistant Professor at TIM/TUHH, and
Dr. Dieter Ernst, Senior Fellow at East-West Center

Project duration: January - December 2007

Executive Summary

In recent years India has emerged as a major destination for corporate research and development (R&D), especially for multinational corporations. India's domestic institutions like Indian Space Research Organisation (ISRO), Defence Research and Development Organisation (DRDO), and the Centre for Development of Advanced Computing (C-DAC) have set prestigious milestones of international standards. Not surprisingly, at Governmental levels a number of international cooperation agreements in the field of science and technology have been signed with India. After years of self-imposed seclusion, principally motivated by post-colonial India's insistence on the "development of indigenous technology", India finally seems to have joined the global mainstream of innovation.

In January 2007 the Institute of Technology and Management at Hamburg University of Technology (TUHH) launched a research project titled "India's Innovation System: Exploring the Strengths". The one-year project was initiated in cooperation with Honolulu-based East-West Center. The aim of the project was to better understand the emergence of India as an increasingly important R&D hub for both large and medium-sized multinational firms, which in a certain sense may be regarded as curious since India is generally thought to suffer from disadvantages caused by poor infrastructural facilities, red tape and corruption. This project therefore aimed to examine, evaluate and ultimately comprehend the elements and inherent strengths and weaknesses of India's innovation system and its chances for the global economy, particularly in knowledge-intensive sectors.

A preliminary field study was carried out in National Capital Region of Delhi in February 2007, by conducting 22 explorative talks / interviews. The participants included Government officials dealing with issues related to India's National Innovation System, researchers and senior level management of some publicly-funded research institutions, one representative of a major industry association and some privately-held firms. Later in summer 2007 a 6-weeks field research was conducted by the authors in the National Capital Region of Delhi, Ahmedabad, Mumbai, Pune and Bangalore. In addition to that a small number of pre-operational interviews was conducted in Germany. The authors interviewed representatives of private firms as well as Governmental / institutional bodies (85 in total). This study is unique in the sense that it not just undertakes an extensive effort to bring out comprehensive, factual data on various components of India's innovation system – many hitherto not widely known – but also in the sense that it enables an empirical characterization of this system as perceived by various stakeholders, both domestic and foreign.

Based on our research we draw the following picture concerning India's Innovation System of today:

India is in the process of emerging as a major R&D hub for both large and medium-sized multinational companies in various industries. This development is mainly owing to the availability of skilled labor produced in world-class elite institutions. Cost advantages, e.g. in the form of low wages are still present but receding due to substantial wage hikes often ranging between 15 and 25% per annum. The striking finding is however about market-driven factors. Of late, India's market potential, in the meantime ranked as 3rd largest worldwide by the Global Competitiveness Report 2007-08, has emerged as a crucial driver. Rising income levels of India's billion-plus population are creating unique market opportunities for firms, both domestic and foreign.

In India the Government has historically played a major and in most cases a singularly positive role in the formation of its innovation system. India, ever since its independence from British rule, has invested much time, resources and efforts in creating a knowledge society and building institutions of research and higher education. Despite explosive population growth literacy rate in India grew from 18.3% in 1950-51 to 64.8% in 2001 thanks to concerted Government efforts; female literacy rose from a mere 8.9% to 53.7% in the same period. Moreover the quality of education in India is generally ranked as very good. According to the Global Competitiveness Report 2007-08 the quality of mathematics and science education in India is ranked as 11th best in the world, much ahead of 29th placed Japan, 36th placed Germany, 45th placed United States and 46th placed United Kingdom.

Nevertheless, India is faced with major challenges related to infrastructure and bureaucratic hurdles. The quality of education, notwithstanding such excellent rankings as stated above, in many institutions does not reach the standards required for (cutting-edge) R&D efforts. Moreover, a booming economy is leading to shortage of qualified and experienced skilled labor – which result in inflationary wage growth and high attrition rates, which generally lay in a double-digit range.

With the Government maintaining a pro-active role many of these problems may however be expected to get resolved to a manageable extent. In its Eleventh Five Year Plan (2007-12) the Government has announced massive investments in infrastructure and education sectors to enhance both the quantity and the quality.

Industrial firms in India have recognized their chances and are investing heavily in R&D capacities. India is also a beneficiary of global mobility and exchange of talents, technology and resources as much as the world, especially the developed Western countries, have profited from India's export of brain power.

In sum all these developments raise hopes for a further improvement in the conditions of India's National Innovation System.

Table of Contents

List of Figures

List of Tables

List of Boxes

List of Important Abbreviations

Approx.	Approximately
ARAI	Automotive Research Association of India
ASSOCHAM	Associated Chambers of Commerce and Industry of India
BSE	Bombay Stock Exchange
CII	Confederation of Indian Industry
CSIR	Council of Scientific and Industrial Research
DBT	Department of Biotechnology, Government of India
DSIR	Department of Scientific and Industrial Research, Government of India
DST	Department of Science and Technology, Government of India
GOI	Government of India
Govt.	Government
IIM	Indian Institute(s) of Management
IISc	Indian Institute of Science
IIT	Indian Institute(s) of Technology
ITI	Industrial Training Institutes
MD	Managing Director
MST	Ministry of Science and Technology, Government of India
NASSCOM	National Association of Software and Service Companies
NCR	National Capital Region (of Delhi)
NCVT	National Council for Vocational Training
NIT	National Institute(s) of Technology
NMITLI	The New Millennium India Technology Leadership Initiative
NSE	National Stock Exchange (of India)
OECD	Organisation for Economic Co-Operation and Development
Rs.	Rupees (also known as Indian National Rupees)
S&T	Science and Technology
SME	Small and Medium-sized Enterprise(s)
TePP	Technopreneur Promotion Programme
TRIPS	Trade-Related aspects of Intellectual Property rights
TUHH	Technische Universität Hamburg-Harburg (Hamburg University of Technology)
UGC	University Grants Commission
USD	United States Dollar
WTO	World Trade Organization

1. Introduction

In recent years India has emerged as one of the major destinations for conducting offshore corporate research and development (R&D). India's domestic institutions like Indian Space Research Organisation (ISRO), Defence Research and Development Organisation (DRDO), and the Centre for Development of Advanced Computing (C-DAC) have set prestigious milestones of international standards. Not surprisingly, at institutional and governmental levels a number of international agreements for cooperation in the field of scientific research have been sealed. After years of self-imposed seclusion, principally motivated by post-colonial India's insistence on the "development of indigenous technology and efficient absorption and adaptation of imported technology"[1], which sometimes led to little more than reverse engineering of products developed elsewhere, India finally seems to have joined the global mainstream of innovation.

The 2007-08 edition of the Global Competitiveness Report of the World Economic Forum places India on rank 26th worldwide for "innovation and sophistication factors" in the economy, ahead of countries like Spain (31), Italy (32), Portugal (38), Brazil (41), China (50) and Russian Federation (77); see (WEF, 2007).

The Organisation for Economic Co-Operation and Development (OECD) ranks India as being the 8th largest R&D investor worldwide. According to OECD (2006) India's R&D expenditures grew by nearly 8% p.a. on average between 1995 and 2004 reaching USD 24 billion in terms of purchasing power parity (PPP). The European Union (EU) counts India among "major R&D performing countries in the world" (INNO METRICS, 2006). Many other recent studies suggest India to be one of the most attractive locations worldwide for R&D and Innovation offshoring; see for instance studies by LTT Research (2007)[2], the Economist Intelligence Unit (EIU, 2004), A.T. Kearney (2007), Boston Consulting Group (BCG, 2006), and Booz Allen Hamilton (Doz et al, 2006).

Since most of these studies pursue a global perspective, there has been a general lack of empirically-based independent, academic research on issues specific to the Indian context. In 2005 Gupta and Dutta, both scientists with Indian Government's Department of Science and Technology (DST), provided a valuable piece of information on India's National Innovation System mainly dealing with the role of the Government. Only in 2007, after initiation of our project, a few more works dealing with India's National Innovation System have been published; e.g. Bound (2007), CII (2007), Dutz (2007), and Mitra (2007). Additionally, Mani (2006; 2007) has written on India's sectoral systems of innovation, mainly related to the Pharmaceutical industry, whereas Parveen Arora (2007), scientist with DST's National Science & Technology Management information System, has examined the role of the Government in India's "Biotechnology Innovation System". Nassif (2007) undertakes a comparative analysis of national innovation systems as well as of macro-economic policies of India and Brazil.

Despite these recent efforts there remains the general need to connect India's innovation system with India's increasing role as a hub for global R&D. There is only a limited number of "practical" reports and material available dealing with the chances and challenges of innovation offshoring to India from firm's perspective, especially related to India's intrinsic

[1] Government of India's "Technology Policy Statement" in 1983; see chapter 4.
[2] This study was conducted on behalf of the European Commission.

"innovation system". This is despite the fact that India is among those few developing countries, which intensively reflect upon setting up a national innovation agenda, as can be seen in Chapter 3.

Since the Indian Innovation system also encompasses non-Indian (international) firms it seems to be vital to better understand motives and barriers of such firms in order to align these under the perspective of a national innovation agenda. Therefore we conducted this study as a first exploratory step and to prepare a larger scale research in cooperation with a number of leading institutions in and outside of India, namely Council of Scientific and Industrial Research (CSIR) in New Delhi and the East-West Center in Honolulu.

In this paper we report our first findings from a) an intensive literature review and b) a field trip to India in the summer of 2007. Our objective was to better understand the *motives* and *barriers* for innovation offshoring to India from the perspective of large (multinational) and medium-sized companies, which have created local capacities in India with an intention to develop, produce and sell products in India. Furthermore, we looked at firms which use India as a hub for developing and producing products for international markets. While carrying out our interviews with representatives of Governmental/institutional levels and private firms we discussed the various elements of India's Innovation System which we had firstly identified by an intensive literature analysis. We did so to better understand and relate their relevance from the perspective of private run firms taking investment decisions concerning building up R&D capacities in India.

1.1. Definitional Framework

This section sets the definitional framework for this study. First, innovation and the innovation process are briefly defined in order to delineate the scope of this study. Following that the concept of "National Innovation System" is introduced.

In deference to the guidelines set by the Oslo Manual (OECD/Eurostat, 2005) we define innovation, for the purpose of this study, as following:

> Innovation is invention and commercialization of new (or significant improvement of existing) products, processes and/or services. The minimum requirement for an innovation is that the product, process, marketing method or organizational method must be new (or significantly improved) to the firm.

Innovation activities are all scientific, technological, organizational, financial and commercial steps which actually, or are intended to, lead to the implementation of innovations. Innovation activities also include R&D that is not directly related to the development of a specific innovation (OECD/Eurostat, 2005).

Innovations usually do not take place in a static environment. They are rather a result of a dynamic process involving interplay of several firm-internal and external factors. Research and Development (R&D) may constitute a major – though not exclusive – part of the "innovation process". The innovation process encompasses several systematic steps such as requirement analysis, idea generation, project planning, product development and marketing, cf. Verworn and Herstatt (2000). The individual steps may overlap each other and in a simplified process be categorized into 3 broad phases; cf. Tiwari, Buse and Herstatt (2007).

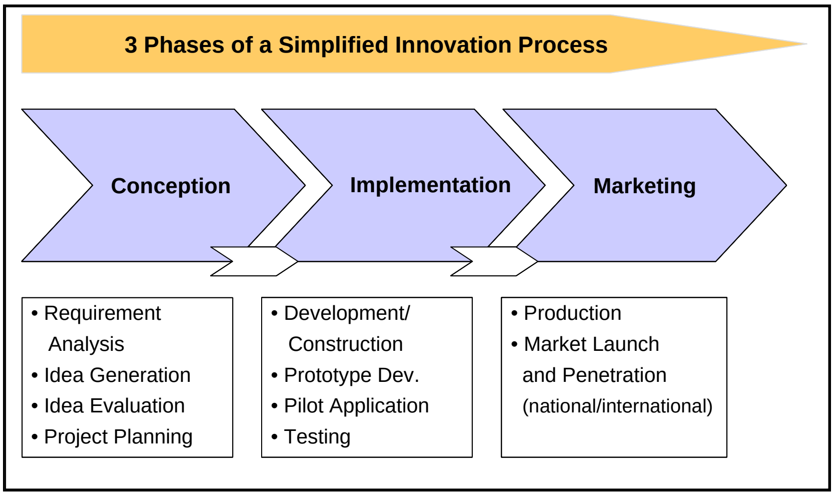

Figure 1: Three phases of a simplified innovation process

Innovation Systems

Innovation systems are country-, region- and/or industry-specific elements which support developing and successfully marketing new products and services.

National Innovation Systems: Definitions

- *" .. the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies."* (Freeman, 1987)
- *" .. the elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge ... and are either located within or rooted inside the borders of a nation state."* (Lundvall, 1992)
- *"... a set of institutions whose interactions determine the innovative performance ... of national firms."* (Nelson, 1993)
- *" .. the national institutions, their incentive structures and their competencies, that determine the rate and direction of technological learning (or the volume and composition of change generating activities) in a country."* (Patel and Pavitt, 1994)
- *".. that set of distinct institutions which jointly and individually contribute to the development and diffusion of new technologies and which provides the framework within which Governments form and implement policies to influence the innovation process. As such it is a system of interconnected institutions to create, store and transfer the knowledge, skills and artefacts which define new technologies."* (Metcalfe, 1995)

Box 1: Overview over definitions of national innovation systems [3]

[3] Source: OECD (1997)

For an in-depth discussion on the concept of innovations systems; see Lundvall (1992), Nelson (1992; 1993; 2007), Nelson and Nelson (2002), Patel and Pavitt (1994), Freeman (1987), Edquist (1997; 2005), OECD (1997), Yim and Nath (2005), and Ernst (2006).[4]

In this paper we take into account only those elements which contribute to the "national-level" innovation system in India. We do not look into regional peculiarities which might exist at the level of individual federal states. Also individual industry sectors may have an innovation system that – at least in certain respects – differs from the overall national one. A "National Innovation System" can be hardly regarded in isolation in today's globalizing world; cf. Ernst (1999). We therefore also dwell – albeit briefly – on issues related to interaction with foreign countries in sections 3.4 and 3.5.

1.2. Methodology

A primary objective of this study was to observe, understand and analyze the significance of the developments in the field of innovation offshoring to India by comprehending the perspectives of national and international firms engaged in such activities in India as well as by appreciating the role and opinion of institutional bodies involved, such as Government, industry organizations and academia.[5]

A secondary objective was to better understand the mechanisms, strengths and weaknesses of the Indian innovation system – based on the insights of representatives from different levels – which motivate or inhibit firms of different size and industries to innovate in India. In this context we further aim to provide decision-makers from selected industry sectors with useful insights while deciding on whether or not to offshore their innovation / R&D activities to India. Apart from this strategic perspective we further intended to identify necessary organizational- and process-related changes that need to be mastered in order to successfully operate in India.

Owing mainly to reasons of capacity and resources we had to limit this work to a manageable number of companies (51 interviews in 40 firms) in selected industries as well as a number of representatives and experts on Governmental / institutional levels (34 interviews in 22 institutions). Of these 85 interviews 10 were conducted in Germany while preparing the final interview guideline. All these firms had R&D interests in India and could provide valuable inputs for the survey to better reflect the ground realities for foreign firms in India. Altogether we interviewed 85 experts in the period of June 26 and August 8, 2007 in the following regions of India: National Capital Region of Delhi (including Gurgaon and Noida), Ahmedabad, Mumbai, Pune and Bangalore.

Concerning our research with companies we talked to first-line managers (mostly the head of R&D, or the Managing Director). Individual talks lasted at least one hour and on average 2 hours. In some cases the discussion went on up to 3 hours. The discussions were guided by a number of research questions (semi-structured interview format).[6] We asked companies for example:

---

[4] Also Michael E. Porter (1990) talks about general conditions conducive to the competitive advantage of firms in a nation (e.g. presence of institutional infrastructure, related and supporting industries). He however does not specifically use the term "National Innovation System". In a later article, co-authored with Furman and Stern, Porter examines the determinants of national innovation capacity; cf. Furman, et al. (2002).

[5] Survey results for research issues related to these aspects are to be published separately.

[6] The full questionnaire is attached as Appendix 4 to this report.

- Which factors played a crucial role for selecting India as a location for innovation offshoring?
- How was this selection done and who from the management side of the firm was involved in the decision-making?
- What type of R&D and innovation-related tasks are fulfilled by the companies in India today?
- What strategies do these companies follow concerning innovation in India (e.g. local adaptor, local developer or global developer)?
- How much do such firms typically invest in R&D and innovation in India (e.g. measured by typical output-related factors like new products/services developed for the Indian market or patent-related activities)?
- What are the motives of such companies and has there been a shift in such motives?
- What is the experience of companies so-far concerning innovation offshoring (e.g. what worked out well, what are the challenges, what turned out to be an issue)?
- How are the overall interaction and coordination with headquarters and other parts of the firm work being managed? How successful is the cooperation between these units?
- How does the coordination with external partners in India (customers, suppliers, contractors and external R&D institutions) work? What is the experience so far by the interviewed firms?
- What are barriers and limiting factors to innovation offshoring to India (e.g. limited access to (human) resources, bureaucracy, access to local funding, etc.)?

In the case of the representatives of Government agencies, industry associations and academic experts we concentrated on discussing specific *strengths* and *weaknesses* of India's innovation system. These talks were important for us in order to develop a more comprehensive picture of India's innovation system and as a hub for innovation offshoring from another (non-business) perspective.

Both, the interviews with representatives from companies of different industries and sizes and expert interviews helped us to better understand the specifics of the Indian innovation system as such as well as the strengths and weaknesses of India as a hub for innovation offshoring from different perspectives (business, Governmental, institutional and academic). Based on this we will further develop a number of hypotheses that will guide our future research and work.

The questionnaire we used for our interviews as well as the list of Governmental or private institutions and firms that participated in our survey are attached in Appendices 1, 2 and 4 to this report. Most identities have been concealed in this paper since prior approval to quote has not been obtained from the majority of the survey participants as yet. In later versions the identities will be published subject to approval by the respective participants.

1.3. Structure of the Study

In continuation to this brief introduction, we will discuss the increasing trend of innovation offshoring and have a look at India as an innovation location in chapter 2.

In chapter 3 we will take a closer look at some key elements of India's innovation system and in chapter 4 we reflect on the role of various institutional players. For this purpose we present factual information on its merits and shortcomings alike. Furthermore, we describe how this system is perceived by the participants of our survey, especially by those foreign firms engaged in R&D activities in India.

Finally, chapter 4 entails a summarizing analysis which shall serve as a basis for developing a set of preliminary propositions in regard to India's suitability, chances and challenges as an innovation location.

2. Innovation Offshoring

The globalization, especially owing to its economic aspects, has led to an intensive integration of world economies. This integration has opened an array of business opportunities as well as challenges for firms. The access to new overseas markets is invariably coupled with increased competition on the home-turf. For this purpose firms, especially those faced with cost-disadvantages in industrialized countries, seek to counter the price-oriented competition from low-wage countries by seeking to be more innovative in their product offerings and production, marketing and management processes; see Tiwari, Buse and Herstatt (2007).

Nonetheless, innovation activities too generate costs which need to be optimized in order to compete with other "innovators", especially so since the outcome and the ensuing commercial success of innovation efforts remain to a large extent uncertain. Firms are therefore under pressure to develop products better suited to market needs, reduce development costs while shortening the response-time to customer needs, as shown in Figure 2.

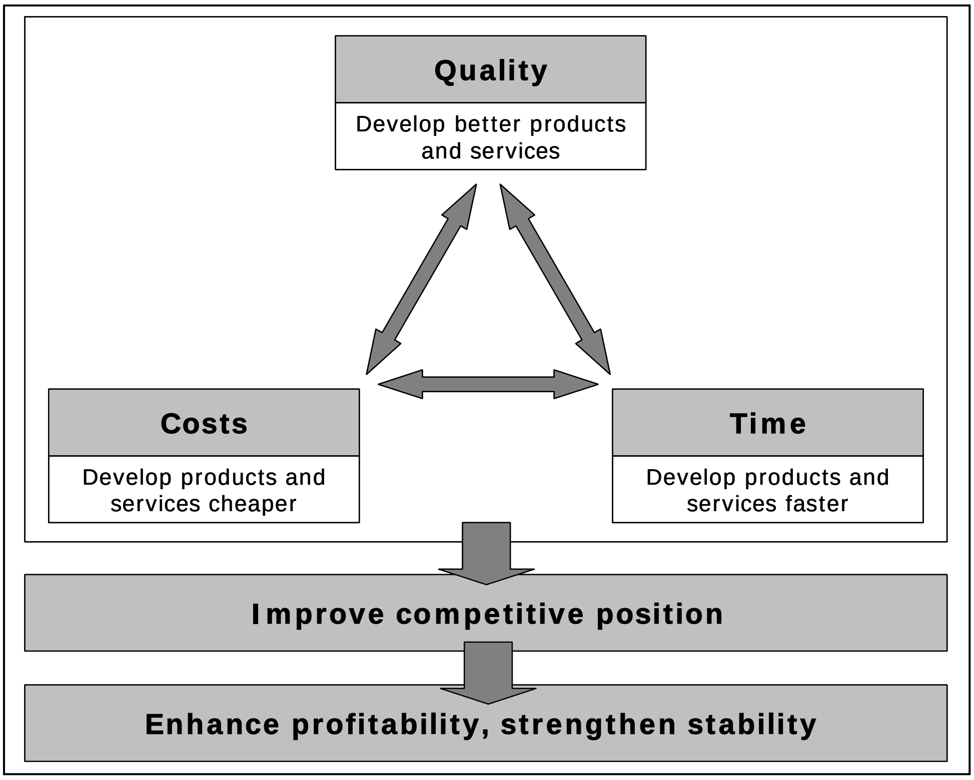

Figure 2: The BCF-Model of Innovation Offshoring [7]

This pressure has led many firms to engage in what we may regard as Knowledge Process Offshoring (KPO), whereby knowledge-intensive research & development work (R&D) is either outsourced to a foreign-based external firm (e.g. contract R&D) or moved corporate-intern to an offshore-subsidiary ("captive offshoring").

Primary motives of KPO are thought to be, for instance, the availability of highly-skilled labor force, cost benefits, location of industry-specific clusters and/or the incentive to develop products designed to suit the specific needs of a target market which is physically and culturally distant from the home market. Over the past decade Asia, especially China, India

[7] Source: Tiwari, Buse and Herstatt, 2007.

and the so-called tiger-countries, have become important locations for such activities labeled as "innovation offshoring".[8] Another significant motive for offshore R&D activities is delivered by barriers to innovation in home country, e.g. shortage of skilled labor, legal restrictions or financial constraints.[9] Such barriers to innovation re-enforce the above-mentioned motives.

2.1. Recent Developments in Innovation Sourcing

Many multinational firms have established R&D centers abroad. The UNCTAD has documented the increasing internationalization of R&D and the role of emerging countries in the innovation process (UNCTAD, 2005a; 2005b; 2005c). Two-thirds of all respondents in an UNCTAD survey in 2005 foresaw a further increase in their R&D expenditure abroad. More than half (57%) of surveyed multinationals already had "an R&D presence in China, India or Singapore", and "Developing Asia is the most often mentioned location for further R&D expansion by firms", reveals UNCTAD (2005b).

In the case of Germany, one third of all firms are reportedly engaged in R&D activities outside of the home base (DIHK, 2005). The stock of foreign direct investments (FDI) in R&D foreign affiliates by German firms increased over 2000% between 1995 and 2003 from a mere USD 43.2 million to an accumulated USD 891.4 million, according to a United Nations Conference on Trade and Development report based on the Bundesbank data (UNCTAD, 2005c). Considering the total R&D expenditure by foreign subsidiaries of German firms the picture is truly revealing. The amount of total R&D expenditure by foreign-based subsidiaries of German multinationals amounted to nearly 11 billion euros in 2003; see Figure 3.[10]

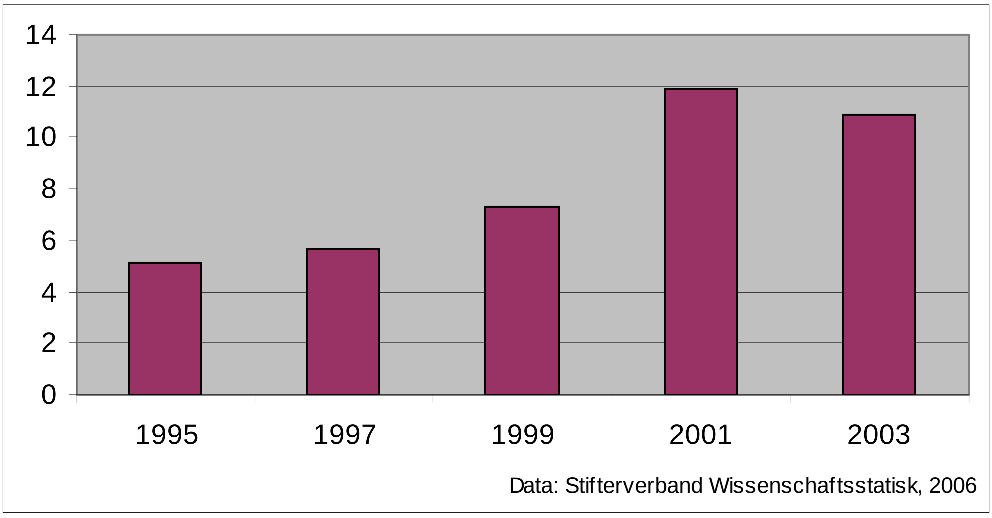

Figure 3: R&D expenditure by foreign subsidiaries of German firms

Also firms in United States of America (USA) spent USD 21.2 billion– slightly more than 13% of their overall R&D budget – overseas. The number of R&D employees of US firms

[8] For a detailed discussion on "innovation offshoring" see Ernst (2006), or Boutellier (2000).
[9] The possible role of barriers to innovation in offshoring of R&D is discussed by Tiwari and Buse (2007).
[10] At the same time (2001) subsidiaries of foreign firms in Germany spent 11.5 billion euros for R&D in Germany and provided employment to some 73,000 people (Belitz, 2004); also see Grenzmann et al (2006).

overseas increased from 102,000 in 1994 to 124,000 in 1999, as per estimates by United States National Science Foundation (NSB, 2006) and UNCTAD (2005b)[11]; see Figure 4.

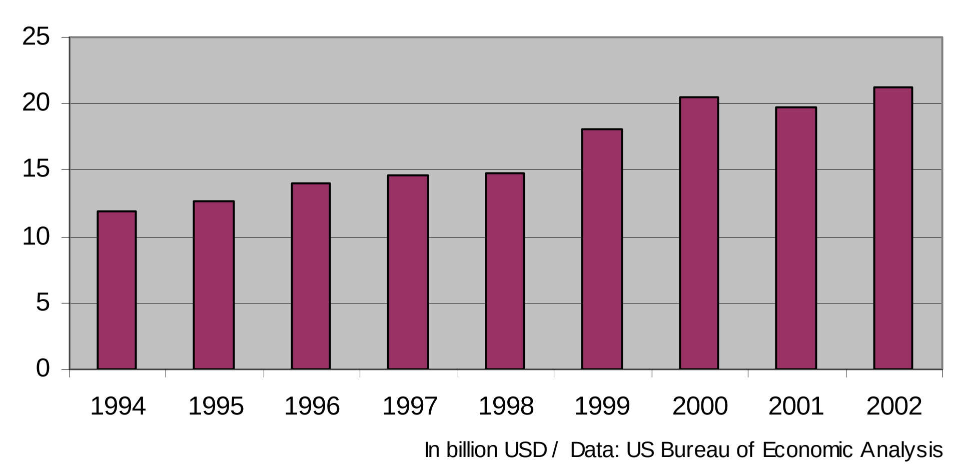

Figure 4: Overseas R&D expenditures by US firms

Another indicator of increased international R&D activity is also corroborated by the evidence from patent data. The share of patents granted by United States Patents and Trademark Office (USPTO) to domestic firms on inventions made either exclusively by foreign affiliates or with their participation rose from 6.5% in 1991 to 10.4% in 2006. In Germany for example the share of such patents granted by European Patents Office (EPO) rose even more impressively from 5.7% to 11.9% in the same period, as shown in Figure 5.

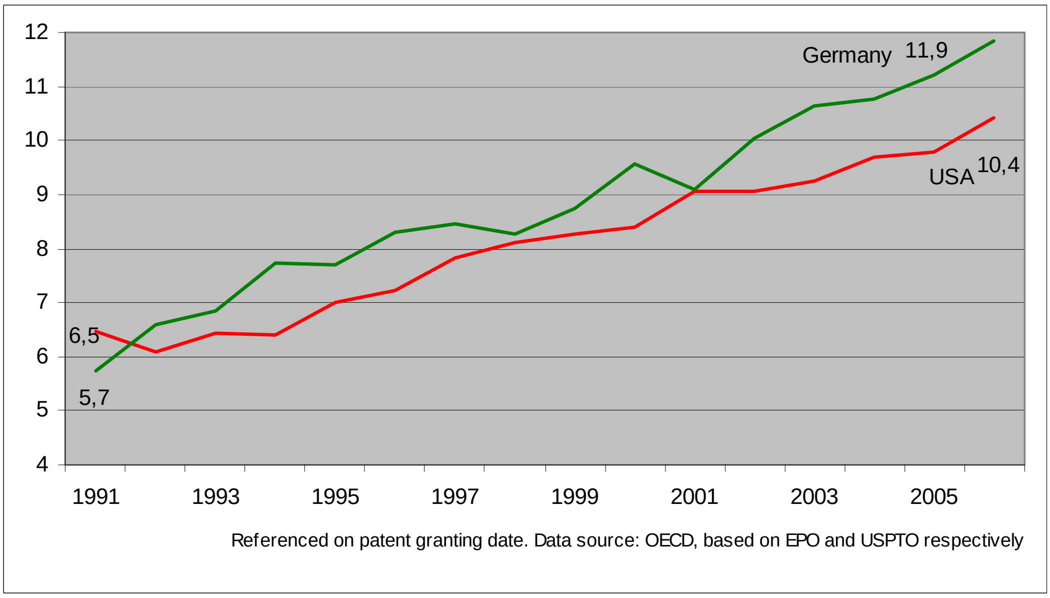

Figure 5: Percentage of shares invented abroad or with foreign participation

The role of foreign subsidiary in corporate strategy

The role of an offshore R&D unit may vary according to its capacities and firm's priorities, as described below:

[11] More recent official data were not available as of Nov. 28, 2007.

i) Local Adaptor

A local adaptor may be considered the lowest unit in the corporate R&D setup. Products (also those for the local market) are conceptualized and developed elsewhere. If any minor arrangements become necessary to adapt the product for local needs (e.g. customization to customer needs) that may be carried out locally. A local adaptor does not have the mandate to make any significant alteration in the product.

ii) In-house Contractor

An "In-house contractor" is generally involved in experimental development, e.g. to build and test prototypes according to specifications set out by the primary development unit. In many cases in-house contractors are those foreign-based units, which have shown excellent capabilities in their role as a local adaptor.

iii) Local Developer

In a growing and promising market foreign R&D affiliates may be given the responsibility to develop certain products for the local market. The products are conceptualized and developed locally, even though prior approvals by headquarters at certain stages may be necessary. Such local developers are usually those affiliates which have proven their capabilities as in-house contractors.

iv) Global Developer

Successful local developers with required capacities may be involved in the corporate R&D strategy at the highest level and promoted to a competence center for certain product fields so that they get the responsibility to conceptualize and develop products for the global market. In some instances the responsibility area may be restricted to "regional" markets, e.g. South Asia in case of an Indian affiliate. In most cases intense cooperation and coordination with the headquarters is necessary. In some cases, though, the complete operational responsibility may be transferred to the foreign affiliate in question.

These roles need not be mutually exclusive, for instance, a unit may simultaneously act in all these four roles for various projects and product fields, as per the needs of the parent corporation. In our survey we found evidence for all these roles for India-based affiliates of foreign firms; see Figure 6.

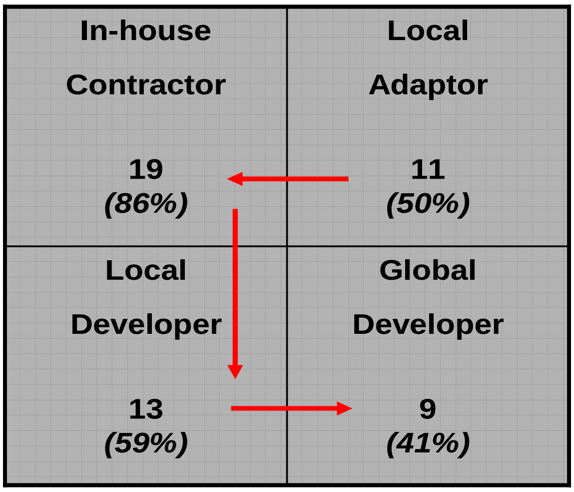

Figure 6: Evolution of the strategic role of Indian unit in firms' corporate strategy [12]

Most firms had transcended the role of a "mere" adaptor. An overwhelming majority (86%) was providing in-house R&D contract services to the parent concern. Notably, many firms were involved in higher level roles as local and global developers, thereby signifying an appreciation of engineering and R&D capabilities of their Indian personnel.

2.2. India as Innovation Location

According to India's National Association of Software and Services Companies (NASSCOM), the revenues of India's IT sector generated by "engineering services, R&D, and software development" have been registering impressive growth (NASSCOM, 2007), as shown in Figure 7.[13]

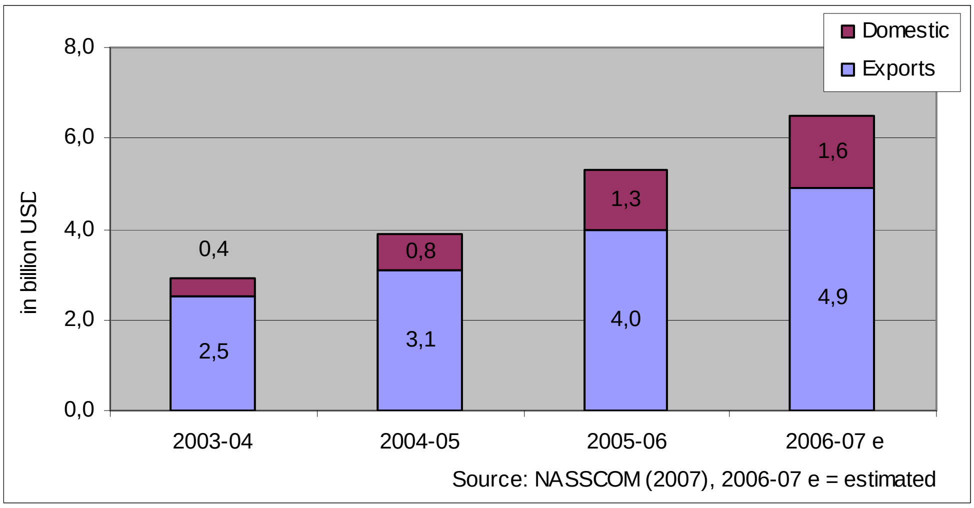

Figure 7: India's revenues with Engineering Services, R&D, & Software Development

India is however not a mere location for software development or IT services. As per calculations by research services group Thomson Scientific, India produced 215,847 published papers between January 1997 and August 2007 catapulting it in the 13th rank worldwide, more so impressive since India had earlier never made it to the list of top-20

[12] R&D performing Indian affiliates of foreign firms (n = 22) in respective categories, in parentheses the share of each category relative to the whole group; multiple options possible.

[13] India's fiscal year runs from April of a given year to March end of the following year.

scientific output countries; see in-cites (2007) and European Commission (2007).[14] The increasing scientific output from India is also reflected in patents granted to Indian inventors.

Figure 8 shows that the number of utility patents granted annually by USPTO to Indian inventors rose from less than 40 in 1993 to nearly 700 in 2006. The stock of US utility patents granted to Indian inventors was 3,951 at the end of October 2007 of which 2,265 (57.3%) were granted to foreign assignees.

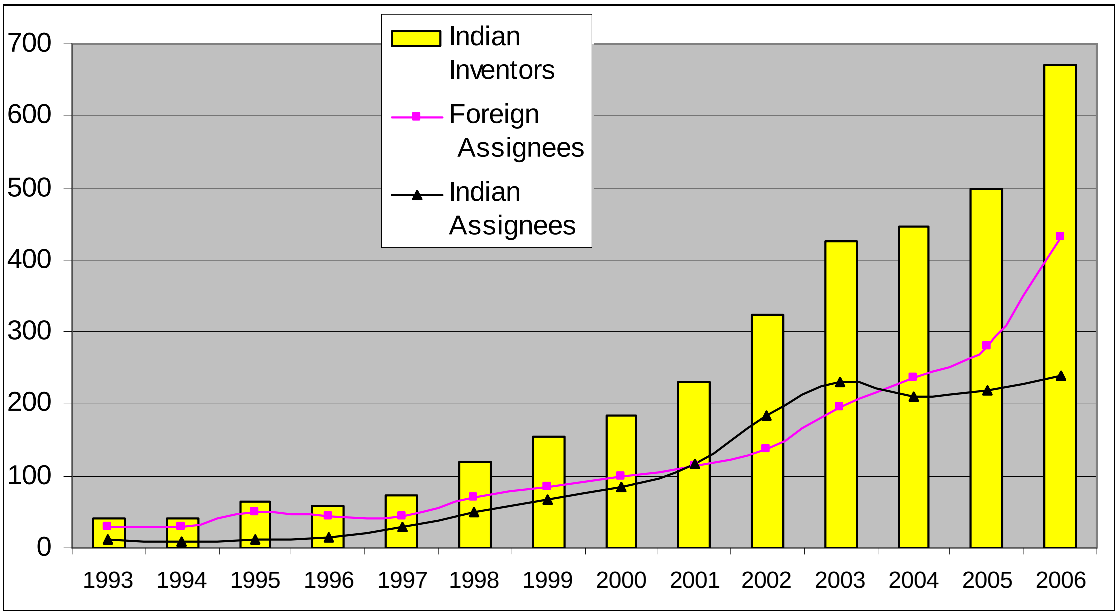

Figure 8: US utility patents granted to Indian inventors, 1993-2006 [15]

In fact, over 100 of the Fortune 500 firms were conducting a part of their R&D activities in India by 2003; cf. Srinivasan, 2004, and GOI, 2003.[16] According to a study by Indian Government's Technology Information, Forecasting and Assessment Council (TIFAC), between 1998 and 2003 India received R&D investment worth USD 1.13 billion. Planned investments in the R&D sectors at the end of 2003 totaled to USD 4.65 billion. The largest investing country was the USA followed by Germany, as shown in Table 1, (TIFAC, 2006).

No.	Country	Companies (numbers)	R&D FDI (Rs. billions)	Planned R&D FDI (Rs. billions)	R&D workers employed
1	USA	53	36.50	12.67	15,901
2	Germany	7	3.46	38.36	2,050
3	UK	7	1.09	1.13	954
4	Japan	7	0.42	7.66	200
5	France	5	0.94	9.93	970
Overall for top-100 R&D FDI companies		**100**	**50.99**	**209.17**	**22,979**

Table 1: An overview of FDI in R&D sector in India, 1998-2003 [17]

[14] Covering a ten-year plus eight-month period, January 1997 - August 31, 2007; see in-cites (2007).
[15] Own calculations based on USPTO data
[16] A currently ongoing research by the authors of this paper shows that nearly 70% of R&D performing Global Fortune 500 companies had established R&D operations in India by November 2007.
[17] Source: TIFAC (2006)

The undoubted presence of foreign R&D affiliates in India may be partially explained by the fact that A.T. Kearney's annually published "Global Services Location Index"[18], ever since its inception in 2004, has been ranking India as offshore location "No. 1" for services, including in the field of high-tech. The reasons cited most often are cost advantages and the availability of skilled workforce. Not surprisingly, 6 of the Top-30 cities attracting Greenfield FDI projects during 2003-06 were located in India and growing fastest worldwide (FDI Quarterly, 2007), as shown in Table 2.

City	Worldwide Rank	FDI Projects	Average growth p.a.
Bangalore	6	550	22%
Mumbai	11	272	56%
Chennai	16	241	72%
Hyderabad	20	221	17%
New Delhi	23	203	43%
Pune	27	174	64%

Table 2: India's position in Top-30 cities attracting Greenfield FDI between 2003-06

As far as "strategic FDI", i.e. FDI in the form of R&D projects or technical support centers, is concerned these 6 above-mentioned Indian cities belong to Top-20 cities worldwide in 2005 (FDI Quarterly, 2005). As the President of a Delhi-based German firm offering business services to German companies in India and a long-term market-insider, puts it, "Offshoring R&D to India has become a 'hot topic' in past 3-4 years". Her statement is indeed corroborated by hard facts, for India has emerged as a prominent R&D hub for foreign firms in recent years. According to international FDI monitoring agency LOCOmonitor ™, India has been in the forefront of the inwards FDI in R&D, attracting the largest number of R&D projects from overseas in last few years, as seen for year 2005 in Figure 9.

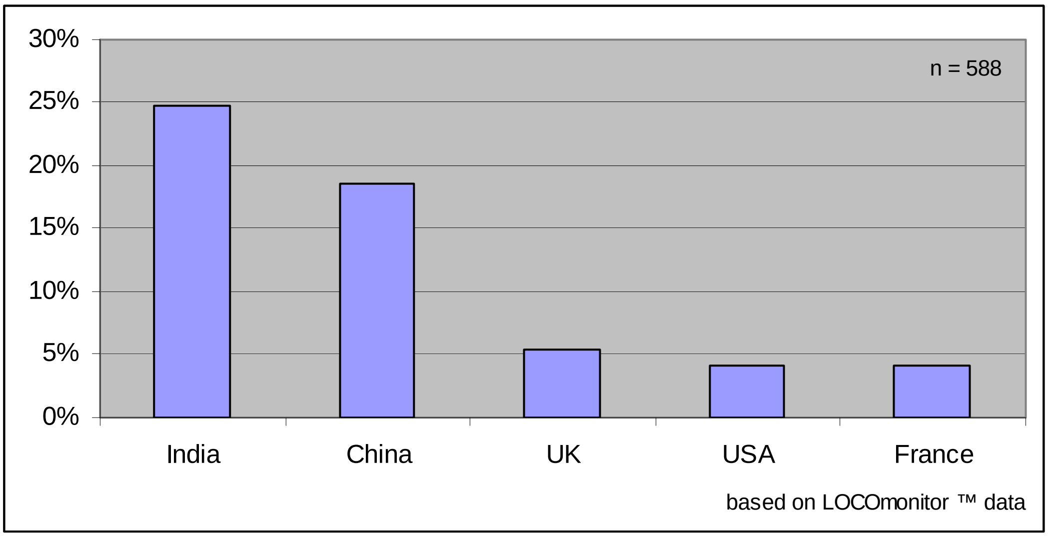

Figure 9: Top-5 destination countries for worldwide FDI R&D projects in 2005

Another study conducted on behalf of the EU identified India as having been the primary R&D FDI destination for EU member countries between 2002 and January 2006 (LTT Research, 2007, p. 76). This report confirms the trend of India being comfortably ahead of China and both of them being much ahead than their nearest competitors such as UK and USA as far as the number of R&D FDI projects are concerned.

[18] In years 2004 and 2005 it was called "Offshore Location Attractiveness Index"

This trend is expected to persist in foreseeable future as most studies continue to identify India as one of the leading R&D FDI destinations. This holds especially true for Life Sciences industries, which according to a Deloitte study are set to witness an increasing role of offshore R&D in next 10 years (Wyke et al., 2006).[19] Similar trends have been reported in Automotives, ICT and other high-tech sectors.

A high ranking official in India's Department of Science and Technology (DST), traces back the roots of these developments in the positive perception of India's capabilities in the field of science & technology (S&T) which, she points out, has taken place owing to a variety of reasons, e.g. global movement of skilled labor from India, India's economic performance, the "Y2K problem", and finally the debate about Outsourcing and Offshoring. "These factors", says this official, "have led to increased media and public attention on India."

Our own survey in India shows a number of reasons to be prominent in India's ascension in world R&D landscape. Figure 10 demonstrates the responses given by all survey participants. In this perspective the market potential in India, coupled with the relative safety of IPRs, the availability of skilled labor on a low-cost basis seem to play a very vital role in India's attractiveness for R&D activities. Further India being a lead market for innovation in certain industries is another and surprising aspect, mentioned by the respondents of our interviews. Taking this together with the expected market potential it seems that the factor market potential is besides the other factors the single most important decision element for firms to further building up R&D capacities in India. Chapter 3 we will describe this in more depth.

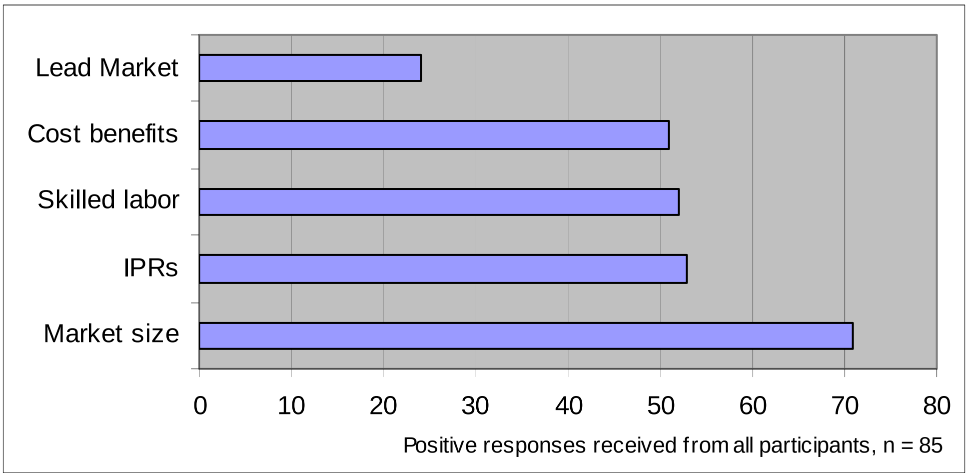

Figure 10: Primary drivers of innovation offshoring to India

The next chapter looks closer at India's innovation system as such which is supposed to support the positive developments described and which in many instances also causes certain challenges to R&D activities in India.

[19] Fabian (2006) delivers a detailed and in-depth study on India's emerging role in pharmaceutical R&D.

3. Some Key Elements of India's Innovation System

"India is faced with various problems in day-to-day life", says a middle-level scientist with Indian Government's DST who is involved in Government's innovation funding programs.[20] "The problem-solving necessitates innovation", articulates this scientist. The necessity to innovate seems to constitute a significant motivation for India's entrepreneurs and public-at-large to seek innovation and also for the Government to promote science and technology in the country. The necessity for innovation, in addition to the overtly recognized wish of its leaders to belong to one of the best in the field of science and technology (S&T),[21] may be considered as one of the primary driving forces behind India's scientific growth; see section 3.2.

The Indian Government has created an extensive S&T network based on public-private partnership. Indian Government's DST describes India's "Science and Technology System" as following:

Figure 11: India's science and technology system [22]

According to the Global Competitiveness Report 2007-08, which places India on rank 26th worldwide for "innovation and sophistication factors", India fares reasonably well in innovation factors for instance, the availability of scientists and engineers and the quality of scientific research institutions. On the other hand India lands on a relatively poor rank (71) as far as Government procurement of advanced technology products is concerned; see Figure 12.

[20] Personal interview conducted in DST, New Delhi on July 2, 2007.

[21] For instance, Indian Government's Department of Information Technology declares its aim as: "to make India a Global Information Technology Super Power and a front-runner in the age of Information revolution".

[22] Source: GOI (2007h).

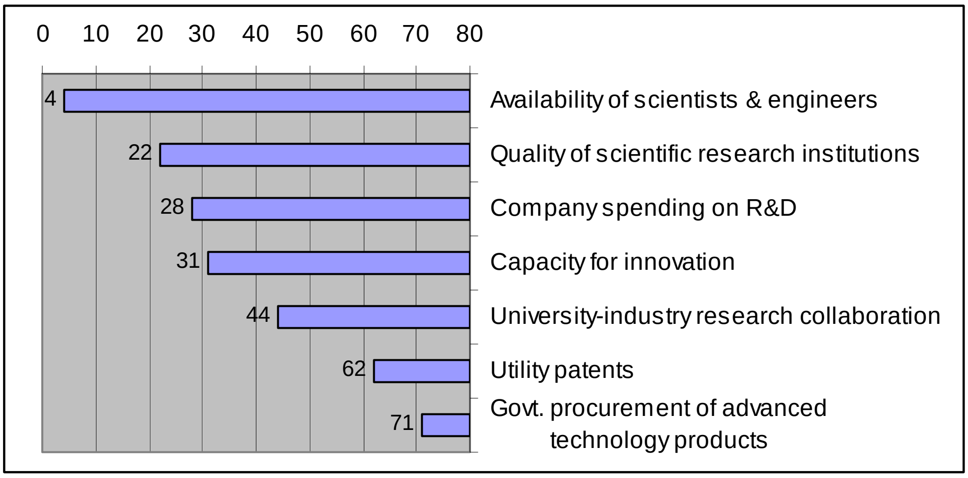

Figure 12: India's rankings in a worldwide survey on innovation factors [23]

In the following we discuss some key elements of India's innovation system. For this purpose we will look at India's R&D efforts, the Indian market, the role of the Government, the educational system (human capital) and the existing industrial network plus infrastructural aspects like service and land infrastructure touching upon some earlier works dealing with the Indian context, for instance Yim and Nath (2005), Gupta and Dutta (2005), and Mani (2006). Only very roughly we will touch value systems, culture, attitudes (e.g. fear of failure or risk-taking) and organizational issues of firms like specific hierarchical elements of Indian firms.

3.1. R&D Resources and Expenditure

India's "well-developed R&D infrastructure", says Christian Kayser, Munich-based Senior Manager of India's leading IT firm Wipro Technologies, "are its' key to success as a leading offshore location". As a matter of fact, at year end 2006 India had a total of 3,960 R&D performing institutions, including in-house R&D facilities in private sector as per Indian Government's Directory of R&D Institutions 2006.

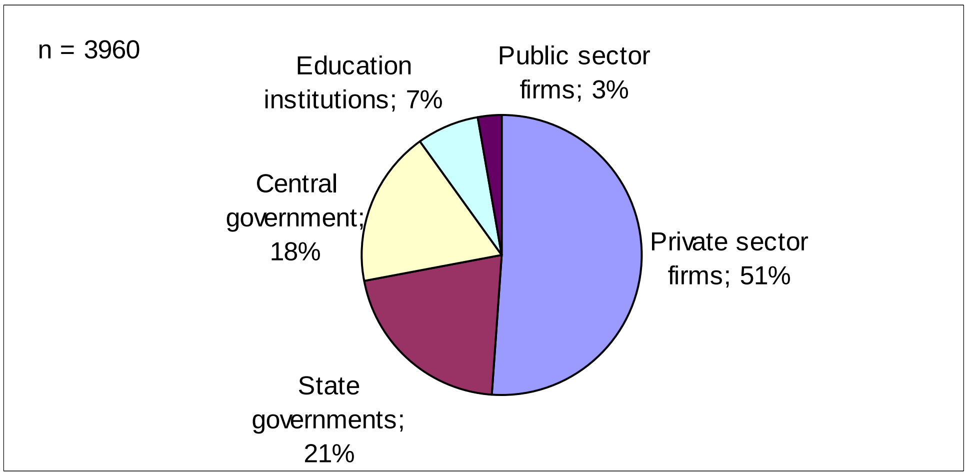

Figure 13: Sectoral affiliation of R&D institutions in India [24]

[23] Based on the Global Competitiveness Report 2007-08; see WEF (2007).
[24] Data: GOI (2006c)

Government sector (i.e. central and state Governments as well as largely publicly funded R&D performing institutions of higher education) accounted for over 80% of domestic R&D expenditure. While industrial sector devoted only 0.47% of its sales turn-over for R&D in 2002-03, only 0.8% of Gross National Product (GNP) was dedicated to R&D; see DST (2006). However, the 8th largest R&D investor of the world has been increasing its R&D efforts consistently. Between 1998-99 and 2004-05 India's overall expenditure on R&D rose by over 73%, as shown in Figure 14. The most impressive growth was registered in the academic sector, whose R&D expenditure grew by 180% in this period.

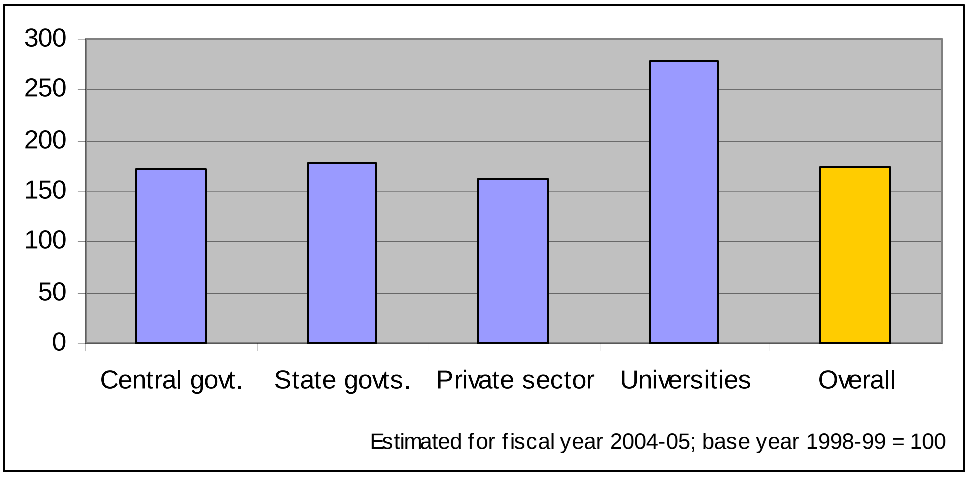

Figure 14: Growth in India's national expenditure on R&D since 1998-99

But even more impressive is the R&D effort undertaken by India in previous 4 decades. Table 3 shows that India's overall expenditure on R&D grew by over 15,000% between 1970-71 and 2004-05. The private sector expenditure on R&D grew from mere rupees 146 million in 1970-71 to nearly rupees 43 billion in 2004-05, registering a growth of nearly 30,000%. Even while making room for inflation impacts, lower starting base and probably better data collection in recent years the growth, undeniably, remains singularly impressive if not exorbitant.

Fiscal year	Central govt.+	State govts.	Private sector	Overall
1970-71	1,124.7	125.8	145.9	1,396.4
2004-05*	14,430.6	18,515.8	42,878.4	216,395.8
Growth	**12,842%**	**14,718%**	**29,389%**	**15,497%**

Table 3: Growth in India's national expenditure on R&D since 1970-71 [25]

As on 1st April 2000, the latest date for which reliable figures are available, there were 296,343 persons employed in the R&D establishments of the country. Of them however, only 31.7% were actually engaged in R&D activities. Over 30% were performing auxiliary (technical support) duties, while 37.9% were providing administrative and non-technical support (GOI, 2006a). The share of administrative staff was especially high in Government sector (43%), whereas in industrial sectors only 16% of the employees were required to manage the administrative and non-technical activities. Even while assuming that a number of administrative staff in industrial firms may be located in a central department and thus not-reported for the R&D department as such, the fact remains that in Government sector R&D

[25] In million rupees (Notes: + = including govt. owned public sector firms; * = estimates), data: GOI (2006a)

institutions only a very small number of employees (24%) were actually performing R&D especially when compared to the industrial sector (65%); see Figure 15; cf. GOI (2006a).

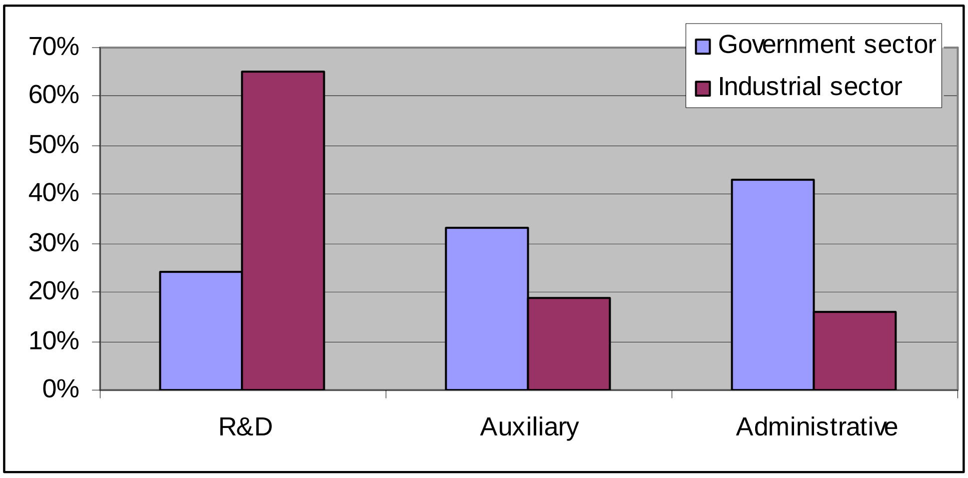

Figure 15: Distribution of personnel by type of activity in R&D institutions

This "imbalance" could potentially cause bureaucratic and procedural hurdles in the functioning of Government sector R&D institutions; as indeed was confirmed by a few participants and mentioned in section 3.2.2.

3.2. Government's Role

Government plays a vital role in any national innovation system, in that it formulates policies that may or may not be conducive to business environment and may or may not reward entrepreneurial quest for innovative products; cf. for instance Singh (2006), Furman et al. (2002), or Porter (1990). It further creates an institutional framework which may in varying degree support basic and advanced research in universities, industrial R&D, and grass-root innovations including in small and medium-sized enterprises (SMEs). The Government also determines whether, in which industry sectors, and to which degree it welcomes foreign participation, e.g. in form of foreign direct investments (FDI) and whether or not it would like foreign firms to engage in R&D activities on domestic soil. In the following sections we describe the Government of India's activities that influence, directly or indirectly – intentionally or unintentionally, India's innovation system.

India belongs to those few developing countries that have deliberately invested considerable time, resources and efforts in creating capabilities in science and technology (S&T). The Government of India has six departments dealing exclusively with matters related to S&T:

1) Department of Atomic Energy
2) Department of Biotechnology
3) Department of Earth Science
4) Department of Science and Technology
5) Department of Scientific and Industrial Research
6) Department of Space

Additionally, there are other Government departments which have major R&D operations; for instance: Ministry of Defence, Department of Agriculture and Cooperation, and Department of Chemicals and Petrochemicals.[26] Government R&D has focused largely on defense and space, which cornered 25.6% and 18% of Central Government's R&D budget in 2002-03 respectively, whereas promotion of industrial development and development of transport and communication languished at 6.3% and 1.5% respectively (GOI, 2006a). This may at least partially explain India's undoubted success in high-tech sectors which however looks somewhat dubious when contrasted with its unmistakable problems in other fields.

3.2.1. Science and Technology Policy

Since independence from the British rule in 1947, India has been investing a significant part of its resources, as discussed in the previous section, in creating quality institutions of higher education and research. In 1958 Indian Government passed a "Scientific Policy Resolution 1958", which stated:

> "The key to national prosperity, apart from the spirit of the people, lies, in the modern age, in the effective combination of three factors, technology, raw materials and capital, of which the first is perhaps the most important, since the creation and adoption of new scientific techniques can, in fact, make up for a deficiency in natural resources, and reduce the demands on capital. But technology can only grow out of the study of science and its applications."

In keeping with this objective the Government has established a number of scientific publications in regional languages for school children and other groups in the society to increase scientific awareness in India, points out a senior official at India's National Council for Science & Technology Communication. These publications are available to public at large mostly at subsidized, affordable rates.

In 1983 the Government of India promulgated a "Technology Policy Statement" which stated "[…] the development of indigenous technology and efficient absorption and adaptation of imported technology appropriate to national priorities and resources" as basic objectives.

Finally, in 2003 a "Science and Technology Policy" was announced, which recognized "the changing context of the scientific enterprise". The new policy has put greater emphasis on innovations to solve national problems on a sustainable basis. For this purpose it even ended the insistence on indigenous development of technology so as to master "national needs in the new era of globalization". One of the concrete, declared objectives is "[t]o promote international science and technology cooperation towards achieving the goals of national development and security, and make it a key element of our international relations".

Dietrich Kebschull, India Representative of the German federal states of Hamburg and Schleswig-Holstein says Indian Government has provided valuable backing for key high-tech sectors such as Biotechnology, Pharmaceuticals, IT and IT-enabled sectors, e.g. by providing "extensive policy and infrastructural support" through setting up of technology parks and continuing strengthening of communication facilities.[27] An official at German Embassy in New Delhi says Indian Government actively tries to foster entrepreneurship, for instance by encouraging spin-offs of R&D institutions to promote technology transfer. "Increase of new ventures (e.g. start-ups) is an important Governmental aim", says this official, who has regular interaction with relevant Indian authorities.[28]

[26] For a comprehensive list of R&D performing Government agencies see GOI (2006c)
[27] Personal interview in New Delhi on 26.06.2007
[28] Personal interview in New Delhi on 26.06.2007

3.2.2. Legal Infrastructure and Policy Frameworks

On its independence India inherited a legal and judicial system based on British lines. An extended Western system largely oriented on British and US models was adopted by independent India's constitution. The Government has been quite active in providing legal framework, e.g. by enacting laws, to address existing and emerging issues in business and S&T related fields.[29] Box 2 and Box 3 provide 2 examples to illustrate this point.

Information Technology in India

Govt. of India established a Department of Information Technology, which among other things seeks to "concentrate on Cyber Infrastructure Protection and to promote the use of Digital Signatures in the financial sector, judiciary and education". As early as 1998 as one of the few developing countries at that time India drafted an "Electronic Commerce Act"; in 2000 an "Information Technology Act" was passed to "provide legal recognition for transactions carried out by means of electronic data interchange". It further enacted institutional infrastructure, for example, in the form of:

- Cyber Laws - Formulation & Enforcement Division
- Controller of Certifying Authorities (CCA)
- Cyber Regulations Appellate Tribunal (CRAT)
- Semiconductor Integrated Circuits Layout-Design Registry
- Standardisation, Testing and Quality Certification (STQC) Directorate

Box 2: Policy and regulatory initiatives in IT sector by Govt. of India

[29] An example is the establishment of an online consumer grievances redressal system (http://www.core.nic.in), a public-private partnership initiative, which through active Government encouragement ensures a legal framework for its operations.

Biotechnology in India

As early as 1982 India established a National Biotechnology Development Board. Subsequently in 1986 Indian Government established a full-fledged Department of Biotechnology (DBT) under the aegis of Ministry of Science and Technology, which in its own words, has evolved "necessary guidelines for transgenic plants, recombinant vaccines and drugs".

In 1986 the "Environment (Protection) Act" was passed to formulate a legal framework for biotechnology in India and supplemented in 1989 with "Manufacture, Use, Import, Export and Storage of Hazardous Micro-Organisms, Genetically Engineered Organisms or Cells Rules". In 1990 "Recombinant DNA Safety Guideline and Regulations" were issued. In 1994 "Revised Guidelines for Safety in Biotechnology" were published, which were supplemented by "Revised Guidelines for Research in Transgenic Plants and Guidelines for Toxicity and Allergenicity Evaluation of Transgenic Seeds, Plants and Plant Parts" in 1998. More recently, in 2006, a Review Committee on Genetic Manipulation (RCGM) was reconstituted with a mandate "to lay down procedures restricting or prohibiting production, sale, importation and use of such genetically engineered organisms or products thereof for research and applications that may have biohazard potential". Further, DBT has formulated "Ethical Policies on the Human Genome, Genetic Research & Services" covering the areas of basic research, genetics, genomics, education and legal aspects, which are harmonized with the UNESCO's Universal Declaration on the Human Genome and Human Rights (1997).

In Nov. 2007 the Government approved a "National Biotechnology Development Strategy" with the aim of laying "a strong foundation for discovery and innovation, effectively utilizing novel technology platforms". It also announced the setting up of a National Biotechnology Regulatory Authority to provide an "independent, autonomous and professionally led body to provide a single window mechanism for biosafety clearance of genetically modified products and processes" (GOI, 2007e).

For a comprehensive overview over Government role in India's Biotechnology sector also refer to Arora (2007).

Box 3: Policy and regulatory initiatives in Biotechnology sector by Govt. of India

The two examples above positively demonstrate how the Indian Government actively seeks to provide an internationally compatible legal platform for emerging technologies and to provide legal security to firms and individuals engaged in those areas. The similarity to Western / British judicial systems is considered by multinational firms as a major asset for India since it gives them a better idea of the system and a sense of security, as the managing director of a German multinational in India concedes.

In non-S&T sectors, however, the Government has yet to modernize the regulatory framework. Some laws still in force were promulgated by the East India Company in the first part of the 19^{th} Century; for instance the Bengal Districts Act of 1836. The Indian Evidence Act and the Indian Contract Act, both relevant for the E-Commerce regulations, were first enacted in 1872. Such acts even though regularly amended and adjusted contribute to a non-transparent legal system since the legal text of just one act is not sufficient, one must normally keep track of all relevant amendments and revisions.

On the other hand in certain areas there are complaints of over-regulation. According to an OECD study (2007) India has a highly restrictive product market regulations regime. The study based on 139 formal rules and regulations with a bearing on competition ranked India as being nearly twice as restrictive as the OECD average. Both administrative and economic regulations were significantly higher than the group averages of OECD Emerging Markets, Euro Area, USA and Latin America.[30]

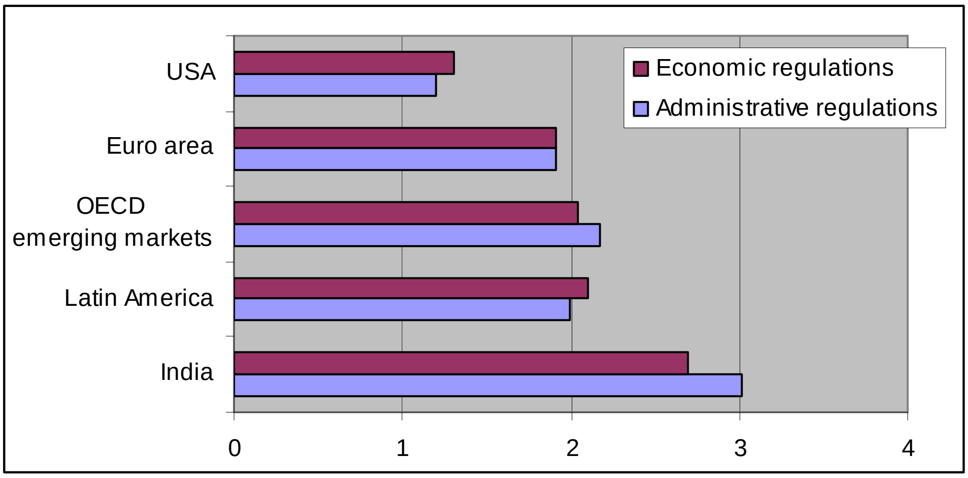

Figure 16: Extent of product market regulations in selected regions [31]

Especially barriers to entrepreneurship in India were ranked as very high in this OECD study, as shown in Table 4.

Indicator: Administrative burden on:	India	Latin America	OECD emerging markets	Euro area	USA
Start-ups in general	**3.82**	2.14	2.61	1.89	1.02
for corporations	**4.25**	1.85	2.82	2.06	0.75
for sole proprietor firms	**4.75**	3.17	2.73	2.10	1.25

Table 4: Selected indicators of barriers to entrepreneurship in selected regions [32]

These findings were confirmed in our interviews in India. Setting up of a firm in India was often termed "a cumbersome process". One respondent with firms in India and Switzerland reported that it took him 6 months to set up a firm (Pvt. Ltd.) in India, but only 7 days in Switzerland. Costs, to the tune of approximately 7,000 Swiss Franks were however about the same in both countries. Another Germany-based industrialist reported that – owing to bureaucratic regulations – it took 6 months to establish just a "liaison office" in Delhi.

The bureaucratic hurdles involved in research work in Government institutions were also confirmed by some insiders on condition of anonymity. These hurdles, narrated the respondents, ranged from inefficient and ineffective project management to refusal of permissions to participate in conferences, even if the author concerned were willing to bear the expenses in his personal capacity.

[30] To be fair, India scores in certain individual categories, such as "Legal barriers to competition" scores that are on par with best practices in the OECD area or even better. The overall restrictions however remain high.
[31] Data: OECD (2007)
[32] Data: OECD (2007)

Several interview partners pointed to bureaucratic and procedural delays as "ground level hassles" of doing business in India. Almost all representatives of foreign companies bemoaned "inflexible labor laws" and some complained of high taxes. The rigidity in Indian labor laws is also confirmed by the Global Competitiveness Report 2007-08, which ranks India on 96th position on this score.[33] Also OECD (2007) confirms this "problem". However, most interviewees recognized on-going Government efforts for reforms and warned against over-emphasizing the perceived negative impacts of policy-related issues.

3.2.3. Intellectual Property Rights

Concerns about the safety of IPRs play a crucial role in any decision regarding R&D activities. Especially SMEs often have strong fears which prompt them to concentrate R&D work at the headquarters; for instance a medium-sized German firm in the sample cited this as a reason to retain R&D in Germany.

The fact that India has signed international treaties for IPR protections, says Mr. Harald Kunze, a lawyer with Rödl & Partner, a German law firm specializing on India, is a positive factor for India. As a matter of fact India in its capacity as a member of the World Trade Organization (WTO) is a signatory to the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS). Further it has signed major international treaties for the protection of intellectual property rights (IPRs), such as the Paris Convention for the Protection of Industrial Property ("Paris Convention") and the Madrid Protocol concerning the International Registration of Marks ("Madrid Protocol").

India has also signed several bilateral agreements, e.g. with the United Kingdom (UK), United States of America (USA), Switzerland, France, Japan and the European Union (EU). The European Patents Office (EPO) is collaborating with the Indian Patents Office to standardize registration processes (GOI, 2007i). Therefore, one might reasonably conclude that India's intellectual property regime, at least on paper, is comparable to that of most advanced economies. The institutional framework is in place. This idea on the Government's part is to support innovation in the sense that it comforts innovators concerning their investments and rights (GOI, 2007i).

The Indian Government has created an extensive network for protection of IPRs in accordance with various international treaties; cf. Abramson (2007). An independent and – at higher levels (High Courts in provinces and the Supreme Court at the national level) – active and well-functioning judiciary have enabled a basic confidence amongst global firms in India. A positive picture of India's IP regime was supported by most of the companies we interviewed during our field research in India: Nearly all respondents recognized the relative safety of IPRs in India and the impartial judicial process by the authorities concerned, as demonstrated in Table 5.

[33] Interestingly enough countries like Spain (95th), France (98th), Brazil (104th) and Argentina (129th) didn't do much better on this score either.

Responses received (59), of them :	**Yes**	**No**	**Partially**
all respondents (n = 59)	**88%**	10%	2%
respondents from organizations with R&D activities in India (n = 31)	**94%**	6%	-
respondents from **foreign** firms with R&D activities in India (n = 17)	**94%**	6%	-

Table 5: Safety of intellectual property rights in India – a positive factor?

Box 4 presents a case study on Swiss pharmaceutical major Novartis' legal battle with India's Government over patent issues. This discussion has attracted much attention in last 2 years and deserves a closer look for understanding India's IPR system.

Boundaries of incremental innovation: Disputed novelty

In past 2 years there has been a major international discussion on the situation of IP protection in India. The discussion was basically caused by India's refusal to grant a patent to Novartis' anti-cancer drug Glivec (Imatinib Mesylate).

Section 3(d) of India's Patent Act of 1970, as amended by Patents (Amendment) Act 2005, effectively holds that the mere discovery of any new property of new use for a known substance is not patentable. The intention is to prevent the practice of "ever-greening", whereby "pharmaceutical companies patent frivolous changes to their drugs in order to extend patent protection, thereby preventing generic companies from manufacturing cheaper drugs […]" (Anderson, 2007b).

In January 2006 the office of the Indian Controller of Patents and Designs (ICPD) denied Novartis a patent for Glivec "on three grounds — anticipation by prior publication, obviousness, priority and also on the ground that the product was a derivative of a known substance" (Sukumar, 2006). The patent office observed "that this patent application claims only a new form of a known substance without having any significant improvement in efficacy" (Sukumar, 2006). Novartis, on the other hand, calls Glivec "one of the medical breakthroughs of the 20th Century", which "has been granted a patent in nearly 40 countries, including China, Russia and Taiwan" (Novartis, 2007). It challenged the constitutional validity of the Indian law in Madras High Court alleging violation of the Article 14 of the Indian Constitution (Equality before law) as well as non-compliance of India's TRIPS obligations. Former Swiss President Ruth Dreifuss, Germany's Development Aid Minister Heidemarie Wieczorek-Zeul as well as several lawmakers from EU and USA called upon Novartis to withdraw the case so as not to hinder the access of the poor to this expensive drug (cf. Anderson, 2007b).

The Madras High Court however rejected the two petitions filed by Novartis as it did not see any violation of the Article 14 of India's Constitution. Further, the Court held that it had no jurisdiction to examine the compliance of the Indian law with an international treaty like TRIPS and therefore advised Novartis to seek recourse with the Dispute Settlement Body of the WTO; cf. the Madras High Court Judgment dated August 6, 2007 disposing Writ Petitions Nos. 24759 and 24760 of 2006.

Novartis criticized the decision sharply and reacted by shifting unspecified R&D investments from India to China while saying it would discourage "investments in innovation" in India (PharmaTimes, 2007).

For further readings see: Anderson (207a/b), David (2007), Indian Express (2007), Mathew (2007), Ollier (2007), Hati (2006) and Chaudhari (2005)

Box 4: Novartis' battle over patents in India

Without going into actual merits of the Novartis case, it may be said that the decision was made in a transparent, judicial process based on laws enacted by India's parliament so that a Government-tolerated, systematic violation of IPRs is not to be found. In this light it is not surprising that an overwhelming majority of respondents did not see any serious IPR problems in India, as seen in Table 5.

The "impartiality" on the Government's part, however, does not necessarily result in optimal conditions; long, delayed and often cumbersome legal processes, even if equally inefficient to all concerned, do not help matters. Owing to this lack of efficient mechanisms to deal with legal issues, which are particularly hard for SMEs since they often do not have resources to fight till High Courts or even the Supreme Court.

No incidences of IP-theft were narrated in our interviews. India, in fact, was portrayed by many interviewees as a better choice than China for R&D operations. Some of the problems reported were the general lack of knowledge of IPRs and patent issues especially in non-formal sectors in India. A German embassy official also pointed out delays in granting of patents caused by the lack of qualified staff in India's patent offices. The situation overall was however rated as relatively good.

3.2.4. State-induced Incentives for Innovation

The Government has launched several innovation funding programs. According to information provided by the Technopreneur Promotion Programme (TePP) at Department of Scientific & Industrial Research S&T budget has been increased significantly in previous years. "No project application", recounts an official, "has been rejected on account of financial constraints". 20 outreach centers have been established in various parts of the country to facilitate support programs.

Whereas focus of the funding programs was up to 2007 as such on innovations and not on particular sectors, in the 11th Five-Year Plan (2008-2012) the focus is to be put on "niche technology areas" like nanotechnology, biotechnology and ICT.

The processing time for TePP applications is typically just 3 to 4 months with 20% acceptance rate. "Rejections", asserts an official working with TePP, "are invariably given with feedback". Another senior official in DST points out that all scientific ministries at administrative level are headed by scientists and technologists. The posting of scientists in key positions in Ministry of Science and Technology (MST), the nodal agency in the Government for funding innovation projects and incubating activities, says this official, are done deliberately to ensure that there is less bureaucracy in the functioning.

Another senior Governmental official involved with funding programs mentioned the lack of interaction and concerted and coordinated effort on part of various Government agencies and cited the example of DST and Ministry of Human Resources and Development (MHRD). Whereas most universities come under the purview of MHRD, funding projects are coordinated by DST. The challenge, says a DST scientist, is to bring "grass-root level into contact with the formal sector, universities and other research centers". For this purpose a "National Innovation Foundation" has been established. In Dec. 2007, India's Department of Telecom announced a USD 2.5 billion package to fund innovations in communications technologies. Entrepreneurs, SMEs, universities and NGOs that have developed communication technologies may seek funding for the "commercial roll-out of their innovations", especially those "linked to improving quality of services or making telecom operations more economical" (Philip, 2007). Also the he New Millennium India Technology Leadership Initiative (NMITLI) program is worth mentioning. This program has been launched with an intention to go "beyond today's technology and [.] seeks to build, capture and retain for India a leadership position by synergising the best competencies of publicly funded R&D institutions, academia and private industry". The Government "finances and plays a catalytic role" in this process; cf. CSIR (2008).

An official at German Embassy in New Delhi says local Government supports those foreign SMEs that don't have enough resources to start their own R&D units, by providing facilities / incubators, especially via research institutions like Indian Institute of Science (IISc) and Society for Innovation and Development (SID), both in Bangalore, to settle down in India and also to cooperate with local research institutes and firms.

Additionally, India also offers tax incentives for R&D operations in the country. For example, expenditure incurred on R&D may be deducted from corporate taxes with a weighted average of 150%. For a detailed account of financial incentives, see DSIR (2006).

3.3. India as a market

India is one of the largest economies in the world and in purchasing-power parity its GDP advanced to third position worldwide behind USA and China and overtaking Japan in 2006. The Indian market and its over one billion population, represents lucrative and diverse opportunities and high prospects for growth and earning potential in practically all areas of business.

According to World Investment Report 2007, affiliates of foreign-based TNCs in India registered a turn-over of 22.3 billion USD in 2003, marking an increase of 17.6% over previous year (UNCTAD, 2007, p. 283). Per capita income in India has been growing impressively ever since India began with economic liberalization in 1991. Between 1991 and 2007 India's per capita income nearly trebled from 331 USD to an estimated 965 USD in 2007 and is estimated to reach 1089 USD by 2008 according to IMF (Figure 17) – this growth is especially noteworthy since India's population grew from below 900 million to an estimated 1.2 billion in the same period.

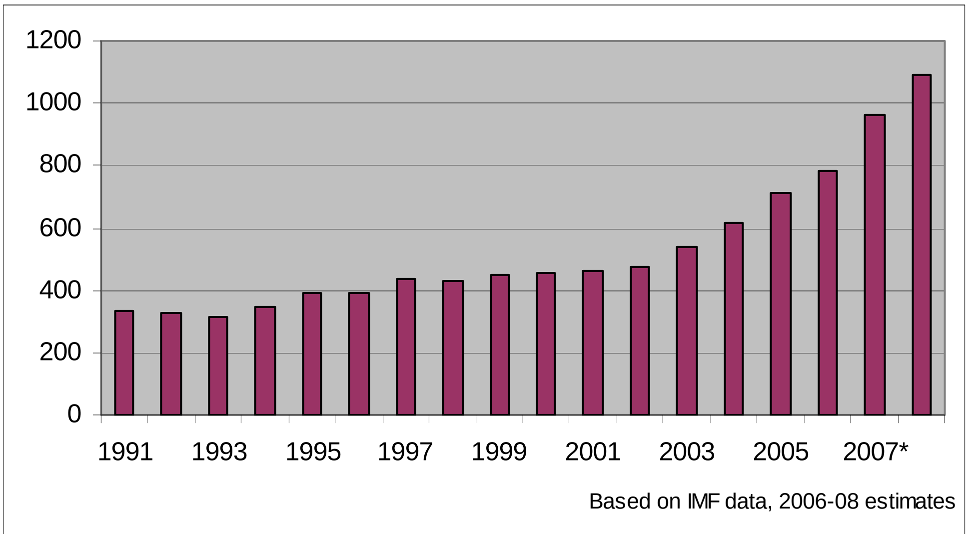

Figure 17: Growth in India's per capita income (1991-2008) in USD

Even more impressive is the growth in per capita income when measured in India's national currency. India's per capita income grew six-fold from approx. rupees 7,500 in 1991 to an estimated rupees 44,533 in 2008. According to a study by McKinsey (2007) incomes in India are expected to grow by a compound annual growth rate of 5.3% between 2005 and 2025, the growth in urban areas will be even higher at 5.8% per annum. Rising incomes of India's households are expected to give a further thrust to consumption in India.

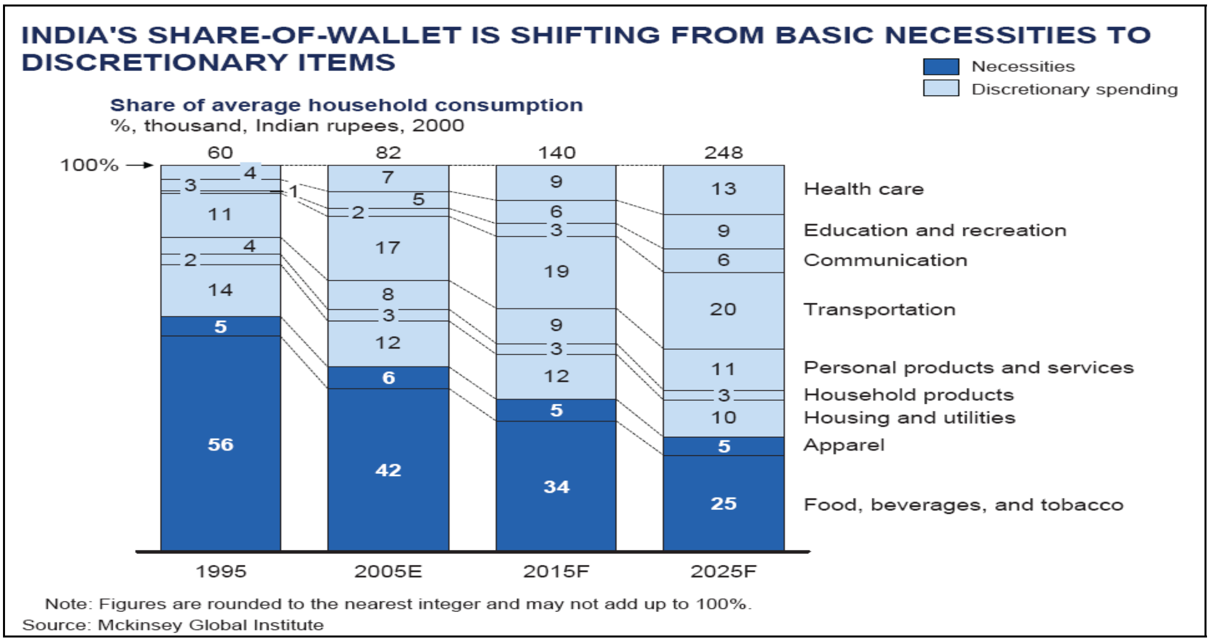

Figure 18: Long-term trends of India's changing consumption patterns [34]

India's infrastructure, transportation, energy, environmental, health care, high-tech, and defense sector requirements for equipment and services will exceed hundreds of billions of dollars in the mid-term as the Indian economy expands and consumption patterns change.[35]

3.3.1. India as a Lead Market

Unsaturated, emerging middle-class consumer market of India is growing into the role of "lead market"[36] for certain products especially electronic goods and automotives with basic functionality, less over-engineering, durability and affordable prices; since "prices play a key-role in the decision-making", as one representative of a German automotive supplier in Gurgaon puts it.

In addition to that India has certain societal / cultural and geographical peculiarities. A pharmaceutical major was using India for R&D operations to develop medicine for tropical diseases. An automotive components supplier used India as a global hub for developing horns, since horns in India – owing to their almost excessive use in the traffic – need to pass more stringent tests than any other developing market.

In these capacities the Indian market has a signaling function for other emerging developing countries, especially in South Asia. This was the tenor of almost all firms interviewed that were supplying into Indian market- This view was also corroborated by various respondents from industry associations, Government agencies and others. This – at least for us – surprising result is shown in Table 6: Over 90% of our interview partners confirmed India as having the potential of a lead market.

[34] Source: McKinsey (2007)
[35] For an excellent, German-language description of developments in India see Müller (2006).
[36] For the concept of „lead markets", see Beise (2001)

Responses received (24), of them:	Yes	Partially	"Yes" relative to group*
all respondents (n = 24)	**92%**	8%	28%
respondents from organizations with R&D activities in India (n = 12)	**86%**	14%	36%
respondents from **foreign** firms with R&D activities in India (n = 8)	**80%**	20%	36%

* Share of responses with "yes" relative to all participants including those who did not respond to this particular question.

Table 6: India's potential as a "Lead Market" – an incentive for local R&D?

"Next generations of new economy are thriving in India and are set to increase", says Naveen Varshneya of Mobile Mantra, stating that India is turning into a lead market for E-Commerce applications. A senior level German manager supports this contention: R&D in India is ideal to develop local content for the Indian market and "regional content" for other neighboring countries with similar socio-cultural and economic backgrounds as well as tastes, says Managing Director of a German multinational in Mumbai.

3.3.2. Demand for Localized Products

India's infrastructural deficits, different working procedures and different tastes often require differentiated products.

India's market is characterized by cost-sensitiveness so that in many instances products need to be developed / adapted, which strike a "balance between technical features and costs to manufacture", says a high-ranking official at DST. A large number of potential users are "not technically sophisticated so that products must be fault-resistant" while handling, thereby necessitating local R&D, opines this official. Also Naveen Varshneya is of the opinion that the masses in India need to be the focal point of any market-driven innovation process as "for educated sections global products may be suitable enough". The masses, says Varshneya, are not necessarily looking for "state of the art but cheap products".

Examples for such localized products and services are provided by specially designed, low-cost mobile phones of Nokia (see Box 5), or pre-paid SIM card services by Mobile Network Operators (MNO). The pre-paid SIM cards which may be purchased in street-corner shops and re-charged comfortably at home have "[…] generated considerable value in a country where people are culturally averse to running up huge pending bills (as would be the case with post-paid connections) and where a large number of people get paid small amounts but at more frequent intervals of time" (CII, 2007). Also McDonald's has put in considerable effort to cater to the demands of a culturally different market (many vegetarians) in India. "To succeed in a very competitive snack-foods market in India, the McDonald's food chain introduced new variants […] similar to other Indian forms of vegetarian ("aloo") patties for their burgers." A McDonald's food development centre has been established in Mumbai. "The prototypes developed here have been adopted for mass production and retailing, and commercialized profitably across McDonald's outlets in India and other countries" (CII, 2007).

An Indian Novelty: Cheap Cell Phones

Handset makers like Nokia, Motorola, Samsung, and LG have set up manufacturing operations in India. They are now focused on penetrating the country's rural market, where 75% of India's 1 billion-plus population lives. Because success in the hinterland means lowering the cost of ownership, players have been constantly redesigning handsets to bring down prices.

Unique Phones for India

Nokia is aggressively reaching out to Indian consumers. On May 3 the company unveiled a range of 7 new handsets. With price tags ranging from $40 to $100, the phones offer many voice and data features, and user interfaces in 75 different languages. The Nokia 1200 and 1208 come with a flashlight, localized languages, and a teaching mode.

Since many people in India's countryside often need to share one phone, Nokia's new models include features enabling multiple users for each handset. For the first time, the phones have a call-tracking application and a multi-phonebook to make phone sharing simpler for customers at the bottom of the pyramid.

The sharing of the mobile phone allows many consumers in entry markets to experience the benefits of mobility firsthand, bringing down the cost of ownership, says Soren Petersen, Nokia senior vice-president in charge of emerging markets.

By: Nandini Lakshman, excerpted from Business Week, 04.05.2007

Box 5: Nokia's special phones for the Indian market

3.4. India's educational system

India's pool of skilled labor is often cited as its single largest asset. In our survey a large majority classified the availability of skilled labor as a major driver for R&D activities in India. A significant minority partially agreed with this notion whereas only few rejected this factor completely, see Table 7

Responses received (53), of them :	Yes	No	Partially
all respondents (n=53)	**63%**	1%	**35%**
respondents from organizations with R&D activities in India (n=30)	**60%**	2%	**38%**
respondents from **foreign** firms with R&D activities in India (n=17)	**53%**	3%	**43%**

Table 7: Skilled labor as a driver of R&D activities in India?

This result is not surprising since India with a total enrolment of 244 million has one of the largest formal education systems worldwide, which encompasses 1.18 million schools, 355 universities[37], and 18,064 colleges all together manned by 6.2 million teachers (GOI, 2007c; GOI, 2007d). In addition to these academic institutions there were 136 institutes engaged purely in research activities such as doctorates and post-doctorates (GOI, 2007d). Thanks to concerted Government efforts literacy rate in India grew from 18.3% in 1950-51 to 64.8% in 2001, female literacy rose from a mere 8.9% to 53.7% in the same period, cf. GOI (2006c).

The availability of scientists and engineers in India is ranked by the Global Competitiveness Report 2007-08 second only to Finland, which scores a 6.0 on the scale of 1 (non-existent or rare) to 7 (widely available). Together with Japan and Israel, the 4th placed India scores 5.9, much ahead of the 12th placed USA (5.6), 16th placed Germany (5.4), 28th placed UK (5.0), 37th placed Russia (4.9), 60th placed Brazil, and 78th placed China (4.2). Various other studies, e.g. by Deutsche Bank Research (DBR, 2005); Farrel et al. (2005), and Farrel & Grant (2005) suggest that India has the largest pool of skilled manpower. In the following we examine India's education system that is responsible for producing this talent pool.

3.4.1. School Education

India has 1.18 million schools, which are manned by 3.8 million teachers. Yet, the primary and secondary education in India is often described as neglected. The quality of education especially in Government-run schools is often poor. Education, especially at school level is pre-dominantly a state-domain, i.e. run by individual federal states. The Central Government plays a minor role in this arena. While India's English-based education system is thought to be one of the key advantages for India in the Knowledge Economy, in many Indian states English is not taught until 6th class in Government-run schools.

According to "Missing in Action: Teacher and Health Worker Absence in Developing Countries", a report by the World Bank, both under-staffing and teachers' absenteeism in Government schools is reported to be wide-spread. During "unannounced visits to a nationally representative sample of Government primary schools in India" in 2003 the researchers found that 25% of teachers were absent from school, and only about half were actually teaching. Absence rates varied from 15% in the state of Maharashtra to 42% in the state of Jharkhand (see Kremer et al, 2005 and Chaudhury et al, 2006).

The quality of education in private schools is mostly thought to be better than in Government schools. The quality of education however varies; whereas many schools are reputed for their high-quality education, many others are not much better than other Government-run counterparts. Education in good private schools is expensive and not affordable for many Indian families.

3.4.2. Vocational Training

Some 1,171 polytechnics provide three year diploma courses in engineering; the basic eligibility criteria is passing 10th standard (GOI, 2007d). A rank below polytechnics there are 1,470 Government-run Industrial Training Institutes (ITIs) and 2,577 private institutions called Industry Training Centers, both groups affiliated to National Council for Vocational Training (NCVT). These 4,047 institutions with a seating capacity of 742,330 trainees are mandated to provide vocational training in technical fields (GOI, 2007f; GOI, 2007a) in 107 different "trades" to youths after 8 to 10 years of schooling (Kolaskar, 2007). The IITs impart training in 49 engineering and 49 non-engineering trades (GOI, 2007f).

[37] Including "Deemed Universities" and "Institutes of National Importance".

According to Dr. Ashok Kolaskar of India Knowledge Commission, a Government initiative, an additional seating capacity of up to 200,000 trainees is set up by other Government bodies, such as Department of Information Technology, and Ministry of Heavy Industries and Public Enterprises (Kolaskar, 2007). "Apprenticeship Training is offered to the school leavers and the ITI passed out persons through a network of 20,700 establishments in 153 designated trades […]" with a capacity of 2.54 million training seats.

There are two major challenges for this system. The first is of quantitative nature: The percentage of vocational education in India is "at meager 5% of its total employed workforce of 459.10 million as against 95% of South Korea, 80% of Japan and 70% of Germany", says a recent study by the Associated Chambers of Commerce and Industry of India (ASSOCHAM, 2007).

Another challenge is of qualitative nature. According to a report prepared by India's Planning Commission (GOI, 2006d) for its Eleventh Five-Year Plan (2007-2012) there is a mismatch between skills imparted in these institutions and the skills required in practice. Additionally, the system caters mainly to the needs of manufacturing sector and is not in the position to fulfill the requirements of sectors such as high-tech and services. Also the informal sector, which provides employment to over 94% of all employed Indians, is ignored. For a detailed discussion on strengths and weaknesses of this system, see GOI (2006d).

The Government is seeking to redress these shortcomings. In 2007 the Government announced a scheme to upgrade 1,396 ITIs into "centres of excellence" in specific trades and skills under public-private partnership by providing funds to the tune of rupees 7.5 billion, which amounts to approx. USD 187 million (GOI, 2007b).

3.4.3. Higher Education

Total enrolment in institutions of higher education in India had increased to 11.03 million in academic year 2005-06 (UGC, 2006b). The number of institutions of higher education has been increasing ever since independence from British rule steadily; see Table 8.

	1947	**2006**	**Growth**
Universities	20	355	1,775%
Colleges	500	18,064	3,613%
Teachers in universities and colleges	7,000	488,003	6,972%

Table 8: Developments in institutions of higher education in India [38]

As many as 439 new colleges had been established during academic year 2005-2006, reports UGC (2006b). India's higher education system is widespread, and while the quality of it is mixed, it offers access to a lot of prospective students getting reasonable higher education. Altogether, 355 universities and 18,064 colleges and other institutions of higher education produce 2.5 million graduates a year, of which 300,000 are engineers and 150,000 IT-specialists, cf. UGC (2006a/b). This is in contrast to 70,000 engineers in USA, nearly 33,000 in Germany, and 600,000 in China (DBR, 2005; Farrel et al., 2005; Farrel & Grant, 2005; BMBF, 2007).

[38] Data source for 1947: UGC (2006a), for 2006: UGC (2006b)

With 14 million young university graduates (with seven years or less of work experience) India's talent pool is estimated to be the largest worldwide, overlapping the Chinese talent pool by 50% and that of the USA by 100% (Farrel et al., 2005). Even though the exact number of yearly graduates and post-graduates is subject to certain discussion, the approximate numbers can be gauged from Figure 19 which shows the subject pattern in India's institutions of higher education as in 2005. Nearly one-third of all enrolled students were studying S&T subjects, i.e. Natural Sciences (including Mathematics), Engineering and Technology, or Medical Sciences.

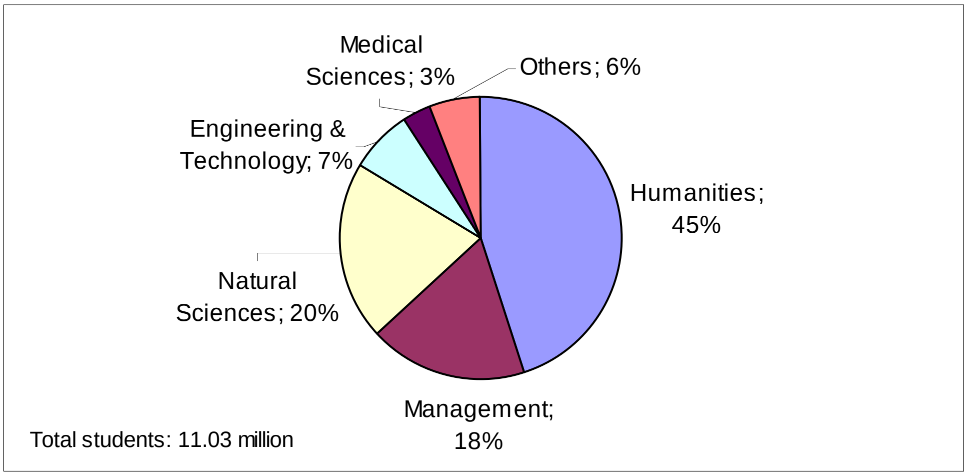

Figure 19: Study subjects of Indian students, March 2006 [39]

In fact, the percentage of S&T graduates in the age group of 18-24 years in India is higher than both in China and USA; see Figure 20.[40]

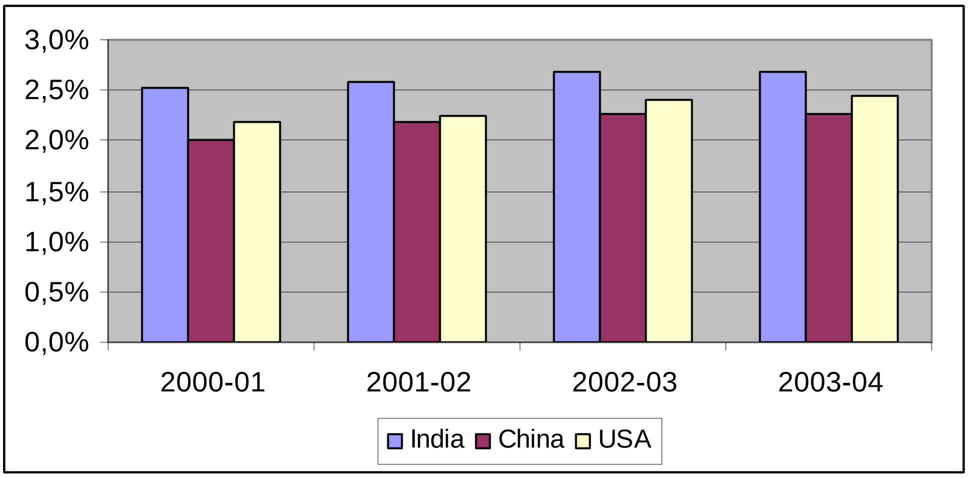

Figure 20: Share of S&T graduates in population aged 18-24 [41]

Figure 21 demonstrates the composition and growth in doctorate degrees awarded by Indian universities, which shows an impressive growth, especially in the field of Engineering and Technology, which have registered a 300% growth since 1992-93.

[39] Data: UGC (2006b)
[40] Also Krishna and Krishna (2005) give insights into availability of research personnel in India.
[41] Source: CII (2007)

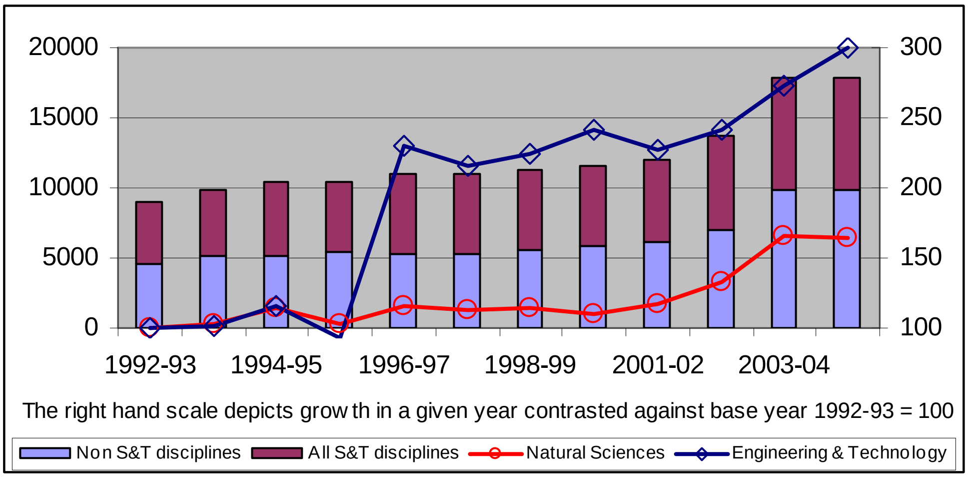

Figure 21: Composition and growth of Ph.D. degrees awarded in India [42]

Three of the top-5 Asian schools for Science &Technology (S&T) are located in India (EIU, 2004). In some fields, especially as far as technical/engineering education at famous institutions like Indian Institutes of Technologies (IITs) or Indian Institutes of Management (IIMs) is concerned, the quality of education is generally thought to be high. But the number of graduates and Ph.D.s passing out from these institutions is not very high. They certainly do not seem to be enough to adequately serve the needs of industry. As a matter of fact more than 320,000 candidates appeared in the IIT Joint Entrance Examination (IIT-JEE) 2008 competing for 5,500 seats across the IITs, the IT-BHU (Institute of Technology – Banaras Hindu University) and ISMU (Indian School of Mines University), Dhanbad, reports the Economic Times (14.04.2008). "About 99% of all entrance examination participants in the IITs, IIMs are rejected due to capacity constraints", reports an ASSOCHAM study (ASSOCHAM, 2007). "The rejected top 40%", says the study, "get admission anywhere in the world provided they pay for it". Over 150,000 students every year go overseas for university education which costs India a foreign exchange outflow of USD 10 billion per annum, an amount that would be sufficient, says ASSOCHAM, to build many IIMs and IITs (ASSOCHAM, 2007).

It may however be argued that India has in many ways profited from this "brain drain", which has proved itself to be a "blessing in disguise". Indian scientists, engineers and technicians especially in USA have proved their mettle and ascended to positions of significant influence. They have either invested themselves in India creating job opportunities or convinced their firms to do so. US-based and Indian-owned venture capital (VC) firms have been "actively funding Indian companies […] so that they can save on research and development costs", says a study by the Word Bank Institute as reported by Press Trust of India (PTI, 2007).

"[…] the quality of graduate research in India lags significantly behind the U.S. and Europe, with a few rare exceptions", writes Prabhakar Raghavan (2007), the head of Yahoo! Research. Raghavan, a graduate of IIT, Madras, is also a consulting professor of computer science at Stanford University and editor in chief of the Journal of the Association for Computing Machinery and serves on a number of policy and editorial boards. His thoughts are echoed by a high-level Indian executive of a global IT giant in Bangalore, who told these authors: "Most of the engineering colleges in India are worth nothing". His firm recruits only graduates from Tier-1 (such as IITs) and Tier-2 universities and colleges (such as NITs), leaving out others

[42] Data for academic years 1992-93 to 2002-03: GOI (2006a); from 2003-04 onwards: UGC (2006b). Data for 2003-04 and 2004-05 are provisional.

completely, he revealed. In fact a "High Power Committee for Faculty Development in Technical Institutions" constituted by All India Council for Technical Education (AICTE), an apex body of the Indian Government, comes to the conclusion that there is a "serious lack of research culture in most of the institutions" in India (AICTE, 2006).

These statements may seem ironic, and even contradictory, "considering that American academia and industry thrive on Indian scientists", contends Raghavan (2007). "The reason", opines Raghavan, "is that graduates from the top Indian science and engineering schools tend to head abroad to do their graduate work, where they frequently excel and settle". The current economic boom in India further exacerbates this: The top graduates who remain in India have lucrative options ranging from IT giants to investment banks. According to Forbes reports from August 2007, all the top five graduates from one Institute of Technology last year had offers from Deutsche Bank**,** see Raghavan (2007). On the situation of higher education, especially challenges faced by it also see Agrawal (2006), and UGC (2003).

One problem reported was that graduates with a Bachelor of Technology (B. Tech.) degree were most sought after. According to a senior-level Indian manager of a German Automotive supplier in India, this phenomenon (most B. Tech. graduates moving to industry and not opting for Masters and Ph.D.s) is eroding India's education system. There are less incentives "to go for higher education"; so that "the best and bright" who earlier became professors opt out of the academia, says a senior-level Indian manager. Faculty positions – in Government dominated universities and research institutions – are no more appealing due to their significantly less attractive compensation packages and the bureaucratic hurdles involved.

The gravity of the problem is confirmed by official reports. The AICTE's "High Power Committee for Faculty Development in Technical Institutions" acknowledges that many teachers in institutions of higher technical education in India do not have post graduate or even doctoral qualification and lack "sustained research accomplishments" (AICTE, 2006). The report confirms that "the gravest problem bedeviling our country's system of technical education is the woeful shortage of competent teaching staff" [AICTE, 2006]. The committee found Indian institutions of higher-level technical education to be plagued by a dramatic shortage of academic staff: "The total shortage of teaching staff", says the committee in its report, "is over 40,000 and the shortage in the different cadres is Professors – 4531, Readers – 9063 and Lecturers – 27187".[43] "The shortage of Ph.D.s", continues the committee in its report submitted to AICTE, "exceeds 30,000 while the Masters' shortfall is over 24,000". "The shortage in the faculty and the inadequacy of the existing faculty in several instances", concludes the report, "are [.] reflected in the alarming failure rate in a large number of technical institutions. For example, in about 150 of the 229 engineering colleges in [the state of] Tamil Nadu, the failure rate was as large as nearly 65%" [AICTE, 2006].

Balakrishnan (2006) sees commercialization of education in India as a root cause for downfall in education quality, as many profit-driven institutions operate "[…] without any concern for the quality of the faculty". The success of India's IT industry is also demanding its price. Graduates of other S&T disciplines are opting for IT carriers and IT is attracting more students. The excessive focus on IT, says a senior scientist in DSIR, is going to lead to a major lack of qualified people in other sectors.

Also the interaction between academia and industry is problematic. Most Governmental academic institutes in India are (still) exclusively Government funded and follow bureaucratic

[43] A "Reader" in the Indian education system is equivalent to an "Associate Professor".

practices. Other institutions are organized outside the university system and have by far more funds for research compared to Governmental universities. But being outside the university system, this not only creates duplications in infrastructure and activities, it keeps teaching and research separate (CII, 2007).

The Government is gearing up to master such challenges by initiating institutional reforms and increasing financial means of the universities. Under the Eleventh Five Year Plan (2007-12) the Indian Government has "increased the outlay for education from 7.7 per cent of the total gross budgetary allocations in the 10th Plan to more than 19 per cent in the 11th Plan while the actual outlays have been virtually raised five-fold", declared Prime Minister Manmohan Singh in December 2007 (The Hindu, 2007). As a follow-up of this decision, the Government has announced plans to set up 8 new IITs, 7 new IIMs, and 14 Central Universities "aiming at world class standards" as well as 16 Central Universities in states "which do not have a Central University at present" (GOI, 2008).

To sum up, India's educational system is in many respects contradictory. Whereas a large amount of money is spent on higher education, primary education in Government-run schools is often neglected. On the other hand, there are thousands of private schools which provide better-quality education with English as a medium of instruction from the very beginning. These, however being expensive, are not affordable for an overwhelming majority. At the level of higher education there are some institutions which are world-class and many others which are far below the average. So that the quality of education provided in Indian schools and higher institutions varies and the degrees are not directly comparable, even if the titles on the certificates are semantically identical.

3.5. Industrial Networks

Good links between industry and academia support innovation. In case of India the situation is still not optimal. The lack of innovation infrastructure or hubs, linking the industry, services, researchers and academics is a major constraint in India. Such centers, national and regional, are still largely missing in India compared to other countries.

Research organizations in India have been "akin to ivory towers pursuing excellence research but without substantial application to India's problems. In addition universities lack adequate resources and incentives; they have limited interaction with industry, the market (customers) so that India's issues have remained largely unaddressed so far (CII, 2007).[44]

A German manager in Delhi, whose firm is running 2 cooperation projects with IIT in Delhi, says there is no "liability of foreignness" to be faced while seeking cooperation, but it is generally difficult to get access to universities and other research institutions as their focus is normally on teaching. A senior level official at IIT Delhi, who deals with the industry for issues related to technology transfer, confirms such issues. India's basically Government funded educational and research institutions are "focused on publication", he says. So that they are more academic oriented and less interested in industry cooperation, comes the confirmation.

There are other problems too. Academic and research institutions often lack proper and modern infrastructure. An Indian manager of a German Automotive supplier in Pune says, "Automotive testing facilities in India are not state-of-the-art – they are at least two

[44] For a study of industrial linkages of Indian universities see Bhattacharya and Arora (2007).

generations behind the international standards". Such issues make it difficult to cooperate with public-sector agencies, says he.

Another reason for largely missing industry-academia cooperation in India is the domineering presence of large conglomerates which often are very much diversified and maintain – to cater to their diversified needs – in-house facilities for design and development work. Because of the presence of such in-house facilities India's large corporate houses often do not seek any outside cooperation in cutting-edge technology projects.

However there are reports of R&D collaborations between Indian firms and certain research institutions par excellence; for instance Tata Consultancy Services (TCS) cooperates with IITs in Mumbai and Madras; Indian Institute of Science (IISc) in Bangalore, Automotive Research Association of India (ARAI) in Pune, and the National Aerospace Laboratories (NAL) in Bangalore (TCS, 2007).

Foreign collaborations by research institutions

There is a great degree of active international cooperation with various countries, which is also encouraged by the Government. An example is the extensive cooperation network with major German organizations engaged in research cooperation, funding and scientific exchange programs, such as the German Academic Exchange Service (DAAD), German Research Foundation (DFG), Konrad-Adenauer-Stiftung, Alexander von Humboldt Foundation, has been established with active support from both Governments. In addition to this India's CSIR and other research institutions have cooperation agreements with renowned German counterparts such as Fraunhofer-Gesellschaft and Max Planck Society. This cooperation underlines on the one hand the importance that the Indian Government attaches to international knowledge and cooperation and on the other hand it is an acknowledgement of the knowledge capabilities of India and its scientists in Germany and elsewhere.

Intra-industry collaborations

Intra-industry cooperation in India, on the other hand, is widely reported to be working well. Industry associations, such as the Federation of Indian Chambers of Commerce and Industry (FICCI), the Confederation of Indian Industry (CII), and other industry-specific associations, e.g. the National Association of Software and Service Companies (NASSCOM) have been actively pursuing industry's interests and have at many occasions taken the lead to initiate common standards, academic cooperation, curriculum improvements, and policy initiatives.

A German Government official, stationed in Mumbai, praises Indian firms as active and innovative. Managing Director of a German multinational in Mumbai says, "Cooperation with Indian partners works excellently; people are communicative, open-minded and interested in technological developments". In all surveyed foreign firms in India the cooperation with Indian partners was generally described as excellent and cordial.

Summarizing, one can say that the situation in India regarding industrial networks presents a mixed situation. The public-sector and/or Government-funded entities are often found to lack an enthusiastic approach to industry partnerships, which may partly be caused by bureaucratic hurdles. Private sector entities, on the other hand, are mostly active and more open to new business opportunities.

3.6. Physical Infrastructure

Physical infrastructure, defined by India's Planning Commission as "road, rail, air and water transport, power generation, transmission and distribution telecommunication, water supply, irrigation and storage" (GOI, 2006e) is one of the key challenges facing India. The remarkable economic growth since commencement of the economic liberalization process in 1991 has put heavy pressure on India's infrastructure. Problems, according to official admission (GOI, 2007g), "include power demand shortfall, port traffic capacity mismatch, poor road conditions (only half of the country's roads are surfaced), and low telephone penetration […]". A report by World Bank comes to the conclusion that "in some fast-growing cities such as Chennai, Bangalore and Hyderabad, the quality of drinking water is getting worse". "No city in India", says World Bank "has water 24 hours a day, seven days a week" (World Bank, 2007).

Especially Production units suffer in India from power-cuts and irregular electricity supply so that most have to create their own alternative arrangements for instance diesel-run electricity generators, which increase the operation cost, according to a German Automotive supplier with its own factory near Delhi. Not surprisingly, India's infrastructural framework ranks on 67th position in the Global Competitiveness Report 2007-08.[45] For a discussion on India's infrastructural challenges also see Heymann et al (2007).

The extent of the problem may be gauged from the fact the ICT hardware segment in India is not able to take off due to the "pre-dominance of the software sector and the lack of infrastructure", as a senior official at DST puts it. Infrastructure costs, e.g. rentals, energy etc. are touching European levels. Traffic jams etc. lead to loss of valuable time. One possible solution is thought to be to shift the facilities to smaller cities or rural areas. This however is fraught with the risk of a higher attrition. Experience shows that 20 to 30% of the employees leave the firm if moved to hinterland. Moreover, smaller towns and semi-urban and rural areas do not have little if any industrial infrastructure. Overall most of our survey participants confirmed the presence of infrastructure related challenges to innovation activities in India.

Responses received (33), of them :	Yes	No	Partially
all respondents (n = 33)	**58%**	14%	28%
respondents from organizations with R&D activities in India (n = 13)	**56%**	16%	28%
respondents from **foreign** firms with R&D activities in India (n = 11)	**64%**	14%	21%

Table 9: Infrastructure problems in India – a hurdle for R&D activities?

The quintessence, however, was that these barriers could be overcome to a certain extent by own investments. For instance, Vice President of an American IT giant in Bangalore emphasized that there were no infrastructure related barriers to innovation for his firm, since it "can create its own state-of-the-art infrastructure". The external infrastructure, e.g. the overcrowded roads, however "affects the productivity of employees negatively", the respondent confessed.

[45] In comparison China ranks on 52nd, Russia on 65th, and Brazil on 78th position.

It may be concluded that the infrastructural issues in India are presenting a hindrance particularly to SMEs, individual innovators and other such researchers which might be facing resource-constraints. So that the institutional infrastructure formed by the Government – more or less – may be able to support only those who are able to cross initial hurdles on their own. Though not reducing the importance of such Government measures in any way,[46] the infrastructural problems certainly lead to a situation where the innovation potential of this vast land may not be utilized fully leading to under-performance.

Indian Government is however investing in modernization and development of infrastructure, e.g. East-West and North-South axis of motor highways, airports and sea ports. Public-private partnerships are actively encouraged. Road network has increased 10-fold in previous years. In the next Eleventh Five-Year Plan (2007-12) the Government proposes to increase the investment in physical infrastructure from 4.6% of GDP at present to 8% of GDP amounting to nearly USD 320 billion; cf. Planning Commission, 2006b. Deutsche Bank Research expects USD 450 billion to flow in India's infrastructure in this period via public-private partnership.

Mr. Kayser of Wipro says Infrastructure in India is "rapidly gearing up to meet the demands of global trade", especially in Tier-1 and Tier-2 cities. "The challenge", says a Professor at Tata Institute of Social Sciences "is to set right priorities, since bad governance leads to false prioritization".

3.7. Financial Infrastructure

One of the key resources for innovation is supply of financial means, for example in the form of raising equity in capital markets, or funding by venture capital or "business angels". The Global Competitiveness Report 2007-08 ranks India on 37th position in the category "Financial Market Sophistication", much ahead of Brazil (73), Russia (109), and China (118). It scored better than even Taiwan (58), and Italy (86). The availability of venture capital in 29th ranked India is judged better than in France (30) or Japan (37).

India has a well-functioning stock market. Two largest stock exchanges are the Bombay Stock Exchange (BSE), and the National Stock Exchange (NSE). The BSE, the oldest stock market in Asia, was established in 1875. One of the biggest stock exchanges worldwide, it has a nation-wide reach with a presence in 417 cities and towns of India. At the end of Nov. 2007 there were 4,879 companies listed at BSE, the market capitalization amounted to USD 1.62 trillion. The NSE provides "fully automated screen-based trading system" in 1,486 cities and towns of India. The NSE had a listing of 1,009 companies at the end of March 2007; market capitalization stood at rupees 51,521.5 billion, which amounts to approx. USD 1.14 trillion.

[46] Active Government support for Industrial R&D, particularly in high-tech, has been instrumental in India's success in Information Technology (IT) sector, Pharmaceuticals, Biotechnology, Atomic Physics, and Space to name but a few.

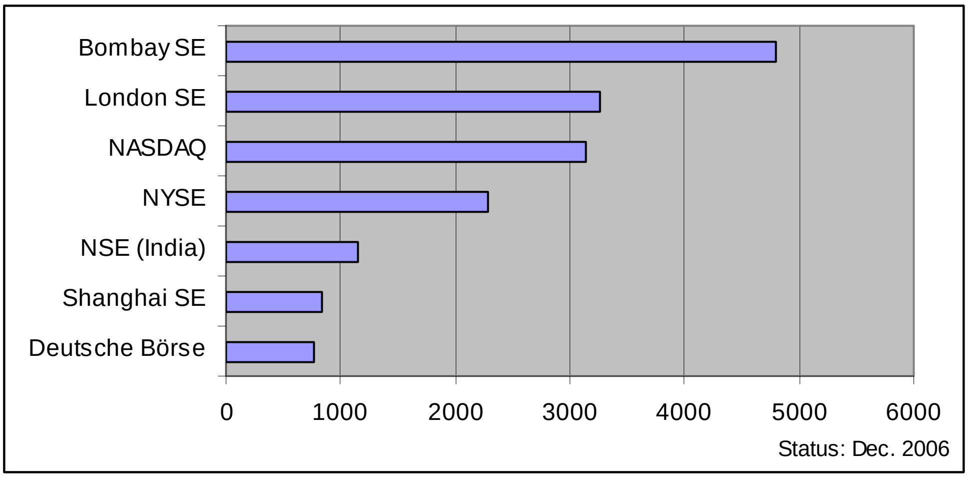

Figure 22: Number of listed companies at selected stock exchanges [47]

An interesting approach to cope with the virtual non-existence of funds and seed capital, especially for incremental innovations from the "grass-root" – mainly in rural areas – was installed by the national innovation centre. The so-called "Honeybee-project", which was created by Prof. Anil Gupta from Indian Institute of Management (IIM) in Ahmedabad, invites individual innovators to present their ideas for funding including intellectual property (patent) support. We regard this activity as extremely important and novel as such, but because of its limited scope it will from our point of view not create major breakthrough innovation – at least not systematically.

3.8. Cultural Aspects and Related Issues

"Indians are good in technical and handyman work – even better than the Chinese", says a Mumbai-based German manager. "The Chinese are however better in mass production", he explained and was seconded – asked or unasked – by many survey participants from outside India. An Indian senior level executive in a globally operating consultancy firm agrees with this notion: "Design-related engineering inputs from simple workers are not possible in China even though they excel in mass production of standardized products". He narrates the experience of one of his German clients who owns manufacturing facilities in both China and India. In India his workers tend to tinker with the production process and improve it. Each time the industrialist would visit his production facilities in India, explains this executive, he would find that the workers have modified the parameters specified in order to resolve some technical snag, whereas in China they would run the machines the same way year after year.

Cultural aspects, being soft factors, are however difficult to determine and judge objectively. Nonetheless they are widely thought to play a major role in a country's innovation system. In this section we describe some of the comments[48] that we heard during our interviews in India.[49]

Positive factors

- "Indians are generally very proficient in learning new processes, particularly those requiring high precision"

[47] Data: World Federation of Exchanges
[48] Made by foreign respondents unless stated otherwise
[49] All remarks reproduced here are given without any evaluation/judgment on our side.

- "Indians are generally courteous, calm, patient and relaxed"
- "Aptitude for developing and improving new (business) processes"
- "Indians are open to new knowledge and 'very much' willing to learn new things"
- "Highly skilled labor is better suitable for complex, non-repetitive tasks"
- "Interaction with Indian business partners is relatively easy, e.g. in comparison to China. To Europeans, the Indians with a history of exposure to the Anglo-Saxon system are in their behavior more predictable than the Chinese"
- "Business dealings are normally hassles-free, taking into account the given cultural factors of the country" Generally no inter-cultural problem; problems faced are mostly at an individual but hardly at a societal level"
- "Indians are good in technical and handyman work – even better than the Chinese. The Chinese are however better in mass production"
- "There is a social shift in India – more competitive, drive to excel" (Indian senior level executive of a global consultancy firm)
- "Indian scientists and technicians have a high adaptability" (Indian head of a research division in a German multinational's lab)[50]

Negative factors

- "Indians are generally late and not prepared for meetings" (Indian Managing Director of an Indian IT firm)
- "Indians still think very much hierarchically – this is reflected in extremely deep organizational structures of firms"
- "More (nominal) positions and titles are required in the organization"
- Attitude to time and punctuality, and keeping deadlines is differing to Western concepts, so much so that implementing a dedicated project management tool like Microsoft Project is simply a waste of resources in India".
- "To confess one's own ignorance or lack of knowledge, and/or the inability to solve certain problems is difficult for many ('loss of face')"
- "Inability to face criticism"
- "The tendency to avoid taking risks leads to a lack of entrepreneurship" (Indian senior level executive of an Indian telecom firm)
- "The answer "no problem" does not necessarily indicate that the task has been understood correctly or that no problems at a later stage are to be expected"
- "The phrase 'we will try our best' often does not mean more than just tactfully rejecting the responsibility for any unexpected or unwanted result"[51]
- "Indians tend to be inefficient in tasks which require to be executed under supervision"
- "Difficult payment practices, bills are cleared late and customers sometime demand rebates after the supply has been made"
- "Attitude towards entrepreneurship and public acceptance of entrepreneurs in India is 'not very developed' – 'people think you are stupid'" (CEO of an Indian IT firm)
- "Some customers face problems due to false handling of products and demand damages for alleged bad quality, some others claim bad quality just to get late rebates"
- "Indians lack a flair for fine, detailed work"

[50] "Germans are too specialized", explained this respondent further, "which makes them very good at doing things in their domain of specialization but it also makes them more inflexible"

[51] This may actually indicate certain uncertainty regarding the outcome or deadline; or it may be simply used for the reason of being polite and not to give a negative answer.

- "Harsh working conditions, e.g. long working hours, take their psychological toll"
- "Professionals are expected to continuously deliver performance par excellence (and often work at odd-hours to synchronize working hours with those abroad) thereby reducing the time for leisure time activities or for the family. In the medium to long-run it negatively affects the productivity and results in the loss of know-how."
- "High attrition rates"

4. Summary

In chapters above we have described how India is gearing up for innovation and related activities. It is emerging more and more as a R&D hub for foreign firms mainly owing to the availability of skilled labor produced in world-class elite institutions and cost advantages, e.g. in the form of low wages and low operational costs. The process of turning from a low-cost provider of routine, standardized tasks into a high-tech center of qualified research and development work has been slow but steady and impressive, nonetheless.

Today, there are hardly any major multinationals not engaged in some sort of R&D work in India. The main drivers are no more just the availability of skilled and cheap labor or cost advantages. The cost advantages in India, in fact, are decreasing by the day due to the sheer magnitude of growth, rising property rates and the resulting demand for skilled labor. India's market potential, ranked as 3rd largest worldwide by the Global Competitiveness Report 2007-08, has emerged as a crucial factor.

Rising income levels of India's billion-plus population are creating unique market opportunities for firms, both domestic and foreign. India's market is showing signs of emerging as a lead market in the segment of functional, fault-resistant and cost-effective goods and services. Necessitated by different cultural background and tastes there is also a large demand for localized product, which encourage R&D/innovation activities in the country and strengthen India's "National Innovation System".

India's Government has historically played a major role in the formation of its innovation system. India, ever since its independence from British rule, has invested much time, money and efforts in creating a knowledge society and building institutions of research and higher institutions. It has consciously and consistently promoted the spread of science and technology in the country. Moreover, it has created and sustained an institutional infrastructure that ensures functioning of a market economy and allows its citizens to invent creative ideas and implement them. Since it began the process of economic liberalization in 1991 it has also supported selected high-tech industries to reach international standards. The Government has constituted fiscal incentives and support funds for spreading R&D in the industry.

Industrial firms in India have recognized their chances and are investing heavily in R&D capacities. India is also a beneficiary of global exchange of talents, technology and resources as much as the world, especially the developed Western countries, have profited from India's export of brains.

Nevertheless, India – still a developing country – is faced with major problems related to infrastructure, e.g. shortage of power supply or transportation problems due to bad logistical infrastructure. In many instances firms and other innovators are faced with bureaucratic and procedural hurdles which often result in corrupt practices and time delays. The quality of education in many institutions does not reach the standards required for (cutting-edge) R&D efforts. Moreover, a booming economy is leading to shortage of qualified and experienced skilled labor – which result in inflationary wage growth and high attrition rates.

With the Government maintaining a pro-active role in both policy and fiscal arena many of these problems may be expected to get resolved to a manageable extent. The Government has announced massive investments in infrastructure and education sectors to enhance both the quantity and the quality. Also, firms in the industrial sector in India – whether domestically or foreign-owned – have recognized their chances and are investing heavily in R&D capacities. These developments raise hopes for a further improvement in the conditions of a National Innovation System, which is unique in the sense that probably no other poor country, starting from a low literacy base of less than 20% in 1947, has ever since its political birth, so consistently and systematically tried to create, nurture and enhance its scientific capabilities and has achieved impressively positive results within such short span of time.

References

A.T. Kearney (2007): *Offshoring for Long-term Advantage*, The 2007 A.T. Kearney Global Services Location Index, A.T. Kearney.

Abramson, B. (2007): *India's Journey Toward an Effective Patent System*, World Bank Policy Research Working Paper 4301, Washington D.C.

Agrawal, P. (2006): *Higher Education in India: The Need for Change*, Indian Council for Research on International Economic Relations, Working Paper no. 180.

AICTE (2006): *Report of High Power Committee for Faculty Development in Technical Institutions*, P. Rama Rao Committee Report submitted to All India Council for Technical Education (AICTE), New Delhi.

Anderson, T. (2007a): *Novartis Case Against India's Patent Law Resumes This Week*, online: http://www.ip-watch.org/weblog/index.php?p=657, retrieved: 27.12.2007.

Anderson, T. (2007b) *Rejected Novartis Cases Leave India's TRIPS Compliance Unchallenged*, online: http://www.ip-watch.org/weblog/index.php?p=712, retrieved: 07.08.2007.

Arora, P. (2007): "Biotechnology Innovation System in India: Role of Government", in: *Proceedings of the 5th International Conference Globelics Russia*, Sept. 20-23, 2007, Saratov.

ASSOCHAM (2007): India's Vocational Education 5% Against 95% Of Sk, 80% Japan & 70% Germany, Press release by the Associated Chambers of Commerce and Industry of India (ASSOCHAM), New Delhi, 19.12.2007.

Balakrishnan, P. (2006): "Higher Education Needs a Longer View", in: *Economic and Political Weekly*, Vol. 41 (32), pp. 3458-3459, Mumbai.

BCG (2006) *Harnessing the Power of India: Rising to the productivity Challenge in Biopharma R&D*, The Boston Consulting Group.

Beise, M. *Lead Markets: Country-Specific Success Factors of the Global Diffusion of Innovations*, Physica-Verlag, Heidelberg, 2001.

Belitz, H. (2004): *Forschung und Entwicklung in multinationalen Unternehmen*, Study on Germany's Innovation System No. 8-2004, Berlin.

Bhattacharya, S. and Arora, P. (2007): "Industrial linkages in Indian universities: What they reveal and what they imply?", in: *Scientometrics*, Vol. 70, No. 2 (2007) 277–300.

BMBF (2007): *Die Bedeutung von Aufhol-Ländern im globalen Technologiewettbewerb*, Studien zum deutschen Innovationssystem Nr. 21/2007, German Federal Ministry for Education and Research (BMBF), Berlin.

Bound, K. (2007): *India: The Uneven Innovator*. London.

Boutellier, R., Gassmann, O., and von Zedtwitz, M. (2000): *Managing Global Innovation: Uncovering the Secrets of Future Competitiveness*, Heidelberg: Springer-Verlag.

Chaudhuri, S. (2005): *TRIPS and Changes in Pharmaceutical Patent Regime in India*, Working Paper No. 535, Indian Institute of Management, Calcutta.

Chaudhury, N., Hammer, J., Kremer, M., Muralidharan, K., and Rogers, F.H. (2006): "Missing in Action: Teacher and Health Worker Absence in Developing Countries", in: *Journal of Economic Perspectives*, Vol. 20, Issue 1, pp. 91-116.

CII (2007): *Innovate India: National Innovation Mission*. Confederation of Indian Industry, New Delhi.

CSIR (2008): The New Millennium India Technology Leadership Initiative, Council of Scientific and Industrial Research, online: http://www.csir.res.in/csir/external/heads/collaborations/NM.pdf, retrieved: 04.01.2008.

David, R. (2007): "Novartis Set Back In India Patent Fight Over Glivec", in: *Forbes*, 08.07.2007.

DBR (2005): *India Rising: A Medium-term Perspective*, Deutsche Bank Research, Frankfurt.

DIHK (2005): *FuE-Verlagerung: Inovationsstandort Deutschland auf dem Prüfstand*, Deutscher Industrie- und Handelskammertag (German Chamber of Commerce).

Doz, Y., Wilson, K., Veldhoen, S., Goldbrunner, T., and Altman, G. (2006): *Innovation: Is Global the Way Forward?*, Joint study by Booz Allen Hamilton and INSEAD.

Dutz, M.A. (Ed.) (2007): *Unleashing India's Innovation: Towards Sustainable and Inclusive Growth*. The World Bank, Washington D.C.

Edquist, C. (2005): "Systems of Innovation: Perspectives and Challenges", in: Fagerberg, J., et al. (eds.): *The Oxford Handbook of Innovation*Oxford: Oxford University Press, pp. 181-208.

Edquist, C. (Ed.) (1997): *Systems of Innovation: Technologies, Institutions and Organizations*, London: Pinter.

EIU (2004): *Scattering the seeds of invention: The globalisation of research and development*, Economist Intelligence unit.

Ernst, D. (1999): *How Globalization Reshapes the Geography of Innovation Systems: Reflections on Global Production Networks in Information Industries*, Proceedings of the DRUID's Summer Conference on National Innovation Systems, Industrial Dynamics and Innovation Policy, Rebild, June 9-12.

Ernst, D. (2006): *Innovation Offshoring: Asia's Emrging Role in Global Innovation Network*, East-West Center Special Reports, No. 10.

European Commission (2007): *ERAWATCH Research Inventory Report For India*, online: http://cordis.europa.eu/erawatch/, retrieved: 15.11.2007.

Fabian, C. (2006): *Internationalisation of Pharmaceutical R&D into Emerging Markets – The Case of India*, Bamberg: Difo-Druck.

Farrel, D. and Grant, A. (2005): *Addressing China's Looming Talent Shortage*, McKinsey Global Institute, San Francisco.

Farrel, D., Kaka, N., Stürze, S. (2005): "Ensuring India's Offshoring Future", in: *The McKinsey Quarterly*, 2005 Special Edition: Fulfilling India's Promise, pp. 74-83.

FDI Quarterly (2005): Strategic Investment Location 2005, in: *FDI Quarterly*, Issue 3, Quarter 4, 2005, p. 3.

FDI Quarterly (2007): Top 50 World Cities – Attracting Inward Investment Worldwide, in: *FDI Quarterly*, Issue 5, Summer 2007, p. 3.

Freeman, C. (1987): *Technology and Economic Performance: Lessons from Japan*, London: Pinter.

Furman, J.L., Porter, M.E., and Stern, S. (2002): "The determinants of national innovative capacity", in: *Research Policy*, Volume 31 (2002), pp. 899-933.

GOI (2003): *Science and Technology Policy 2003*, Government of India, Dept. of Science and Technology, Statement by India's Prime Minister Dr. Manmohan Singh, online: http://www.dst.gov.in/stsysindia/stp2003.htm, retrieved: 21.04.2007.

GOI (2006a): *Research and Development Statistics 2004-05*, Department of Science and Technology, Government of India, New Delhi.

GOI (2006b): *Reseach and Development in Industry: An Overview*, Department of Scientific and Industrial Research, Government of India, New Delhi.

GOI (2006c): *Directory of R&D Institutions*, Department of Science and Technology, NSTMIS Division, Government of India, New Delhi, 2006 (c).

GOI (2006d): *Report of the Working Group on Skill Development and Vocational Training*, Government of India, Planning Commission, New Delhi.

GOI (2006e): *Towards Faster and More Inclusive Growth: An Approach to the 11th Five Year Plan*, Government of India, Planning Commission, New Delhi.

GOI (2007a): *Ministry of Labour and Employment: Annual Report 2006-07*, Government of India, New Delhi.

GOI (2007b): *Key Features of Budget 2007-2008*, Ministry of Finance, Government of India, New Delhi.

GOI (2007c): *Size of the Indian Education System*, Ministry of Human Resources and Development, Government of India, online: http://www.education.nic.in/sector.asp#size, retrieved: 20.12.2007.

GOI (2007d): *National Level Educational Statistics - At a Glance 2004-05*, Ministry of Human Resources, Government of India, New Delhi.

GOI (2007e): *National Biotechnology Development Strategy: Key Elements*, Department of Biotechnology, Government of India, New Delhi.

GOI (2007f): *State & No. of Affiliated ITIs: All Trades*. Directorate General of Employment & Training, Ministry of Labour and Employment, Government of India, online: http://dget.gov.in/lisdapp/nvtis/nvtis.htm, retrieved 19.12.2007.

GOI (2007g): *Investment in India - Investing in India - Venturing into the Indian Market*, Ministry of Finance, Government of India, online: http://finmin.nic.in/foreign_investment/fii/index.html, retrieved: 29.12.2007.

GOI (2007h): *S&T System in India*, Department of Science and Technology, Government of India, online: http://dst.gov.in/stsysindia/st_sys_india.htm, retrieved: 13.08.2007.

GOI (2007i): *Intellectual Property*, Department of Industrial Policy & Promotion, Government of India, online: http://dipp.nic.in/ipr.htm, retrieved: 30.11.2007.

GOI (2008): *Press Note – States identified for locating new central institutions of higher education in the 11th Five Year plan*, Press Information Bureau, Government of India, 28.03.2008.

Grenzmann, C., Kreuels, B., and Wudtke (2006): *FuE-Datenreport 2005/06*, Essen: Stifterverband für die Deutsche Wissenschaft.

Gupta, A. and Dutta, P.K. (2005): "Indian Innovation System – Perspective and Challenges", in: UN-ESCAP (eds.): *National Innovation Systems (NIS) in the Asia-Pacific Region*, New York: United Nations.

Hati, M. (2006): *Does the New Intellectual Property Rights Regime Impede Innovation in Developing Countries: A Case Study of The Indian Pharmaceutical Industry*, online: http://www.globelicsindia2006.org/Moutushi%20Hati.pdf, retrieved: 28.11.2007.

Heymann, E., Just, T., Löwik, L., and Väth M. (2007): *450 bn reasons to invest in India's infrastructure*, Deutsche Bank Research, Frankfurt.

In-cites (2007): *The Year 2007: Top 20 Country Rankings in All Fields*, online: http://in-cites.com/countries/2007allfields.html, retrieved: 18.12.2007.

Indian Express (2007): "So what's new?", in: *The Indian Express*, 07.08.2007.

INNO METRICS (2006). *European Innovation Scoreboard 2006: Comparative Analysis of Innovation Performance*, Initiative of the European Union, online: http://www.proinno-europe.eu/doc/EIS2006_final.pdf, retrieved: 21.04.2007.

Kolaskar, A. (2007): *Vocational Training in India*, online: http://info.worldbank.org/etools/docs/library/235796/5DGET%20World%20Bankm1.pdf, retrieved: 19.12.2007.

Kremer, M., Muralidharan, K., Chaudhury, N., Hammer, J., Rogers, F.H. (2005): "Teacher Absence in India: A Snapshot", in: *Journal of the European Economic Association*, 3 (2-3): 658-667.

Krishna, V.V. and Krishna, U. (2005): "South Asia", in: *UNESCO Science Report 2005*, pp. 241-274, United Nations Educational, Scientific and Cultural Organization, Paris.

LTT Research (2007) *The implications of R&D off-shoring on the innovation capacity of EU firms*, Study on behalf of "PRO INNO Europe" initiative of the European Union.

Lundvall, B-Å. (ed.) (1992): *National Innovation Systems: Towards a Theory of Innovation and Interactive Learning*, London: Pinter.

Mani, S. (2006): *Sectoral System of Innovation of Indian Pharmaceutical Industry*, Centre for Development Studies, Trivandrum, Working Paper no. 3s82, 2006.

Mani, S. (2007): *The incremental innovator Vs the trader: Contrasts between the sectoral systems of innovation of the Indian pharmaceutical and telecommunications industries*, Centre for Development Studies, Trivandrum.

Mathew, J.C. (2007): "NGOs trash MNCs` patent argument", in: *The Business Standard*, New Delhi, 09.08.2007.

McKinsey (2007): *The 'Bird of Gold': The Rise of India's Consumer Market*, Mickensey Global Institute.

Metcalfe, S. (1995), "The Economic Foundations of Technology Policy: Equilibrium and Evolutionary Perspectives", in Stoneman, P. (ed.): *Handbook of the Economics of Innovation and Technological Change*, Oxford: Blackwell, pp. 409-512.

Mitra, R.M. (2007): *India's Emergence as a Global R&D Center - an overview of the Indian R&D system and potential*, Swedish Institute for Growth Policy Studies, Working Paper R2007:012.

Müller, O. (2006): *Wirtschaftsmacht Indien: Chancen und Herausforderungen für uns*, Munich/Vienna: Hanser.

NASSCOM (2007): *Indian IT Industry: NASSCOM Analysis*, online: http://www.nasscom.in/upload/5216/Indian_IT_Industry_Factsheet_Feb2007.pdf, retrieved: 22.02.2007.

Nassif, A. (2007): *National Innovation System and Macroeconomic policies: Brazil and India in comparative perspective*, UNCTAD Discussion Paper 184.

Nelson, R. R. (1992): "National Innovation Systems: A Retrospective on a Study", in: *Industrial and Corporate Change*, Volume 1, No. 2, pp. 347-374, 1992.

Nelson, R. R. (ed.) (1993): *National Innovation Systems. A Comparative Analysis,* Oxford: Oxford University Press.

Nelson, R.R. (2007): "The changing institutional requirements for technological and economic catch up", in: *International Journal of Technological Learning, Innovation and Development*, Vol. 1, No. 1, pp.4–12.

Nelson, R.R. and Nelson, K. (2002): "Technology, institutions, and innovation systems", in: *Research Policy*, 31 (2002) 265–272, 2002.

Novartis (2007): *Glivec Patent Case in India: Fact vs. Fiction*, online: http://www.novartis.com/downloads/about-novartis/facts-vs-fiction-india-glivec-patent-case.pdf, retrieved: 27.12.2007.

NSB (2006): *Science and Engineering Indicators 2006 – Volume 1*, National Science Board.

OECD (1997): *National Innovation Systems*, Organisation for Economic Co-Operation and Development.

OECD (2006): *OECD Science, Technology and Industry Outlook 2006*, Organisation for Economic Co-Operation and Development.

OECD (2007): *OECD Economic Surveys: India*, Organisation for Economic Co-Operation and Development, Volume 2007/14.

OECD/Eurostat (2006): *OECD Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data*, A joint publication of Organisation for Economic Co-Operation and Development (OECD) and Statistical Office of the European Communities (Eurostat), Third Edition.

Ollier, P. (2007): "Novartis loses Indian patent law challenge", in: *Managing Intellectual Property*, London.

Patel, P., and Pavitt, K. (1994), "The Nature and Economic Importance of National Innovation Systems", in: *STI Review*, No. 14, OECD, Paris.

PharmaTimes (2007): *Novartis to move R&D investments to China from India - 23/08/2007*, online: http://www.pharmatimes.com/WorldNews/, retrieved: 23.08.2007.

Philip, J.T. (2007): "DoT to fund innovations in telecom technology", in: *The Economic Times*, 26.12.2007.

Porter, M.E. (1990): *The Competitive Advantage of Nations*, New York: Free Press

PTI (2007): *Diaspora to help India keep edge in outsourcing: World Bank*, Report by Press Trust of India, 03.01.2007.

Raghavan, P. (2007): *India Has The Brains, But Where's The Beef?*, Online: http://www.forbes.com/2007/08/05/india-higher-education-oped-cx_prg_0813education.html, retrieved: 13.08.2007.

Singh, L. (2006): *Globalization, national innovation systems and response of public policy*, MPRA Paper No. 641.

Srinivasan, P. (2004): "Think Research. Think India," in *Business Today*, Issue: 18, pp. 166-167.

Sukumar, C.R. (2006): "Novartis loses patent claim on cancer drug — Patents Controller upholds Natco contention", in: *The Hindu*, Chennai, 26.01.2006.

TCS (2007): *Engineering and Industrial Services: R&D Overview*, online: http://www.tcs.com/EIS/rnd/overview.aspx, retrieved: 07.01.2008.

The Hindu (2007): "Manmohan for institutional reforms in universities", in: *The Hindu*, Chennai, 29.12.2007.

TIFAC (2006): *FDI in the R&D sector: Study for the pattern in 1998-2003*, Technology Information, Forecasting and Assessment Council, Department of Science and Technology, Government of India, New Delhi.

Tiwari, R. and Buse, S. (2007): "Barriers to Innovation in SMEs: Can Internationalization of R&D Mitigate their Effects" in: *Proceedings of the 1st European Conference on Corporate R&D*, Seville, Spain, Oct. 8-9.

Tiwari, R., Buse, S. and Herstatt, C. (2007): *Innovation via Global Route: Proposing a Reference Model for Global Innovation Activities*. Proceedings of the Second International Conference On Management of Globally Distributed work, Bangalore, India, July 25-28.

UGC (2003): *Higher Education in India: Issues, Concerns and New Directions*, University Grant Commission of India, New Delhi, 2003.

UGC (2006a): *Higher Education in India: Emerging Issues Related to Access, Inclusiveness and Quality*, University Grant Commission of India, Transcript of the Nehru Memorial Lecture by UGC Chairman Sukhadeo Thorat, Mumbai.

UGC (2006b): *Annual Report 2005-06*. University Grant Commission of India, New Delhi.

UNCTAD (2004): *World Investment Report 2004: The Shift Towards Services*, United Nations Conference on Trade and Development, 2004.

UNCTAD (2005a): "Globalization of R&D and Developing Countries", *Proceedings of the Expert Meeting*, United Nations Conference on Trade and Development.

UNCTAD (2005b): *UNCTAD survey on the internationalization of R&D: Current patterns and prospects on the internationalization of R&D*, United Nations Conference on Trade and Development, Occasional Note.

UNCTAD (2005c): *World Investment Report 2005: Transnational Corporations and the Internationalization of R&D*, United Nations Conference on Trade and Development.

UNCTAD (2007): *World Investment Report 2007: Transnational Corporations, Extractive Industries and Development*, United Nations Conference on Trade and Development.

Verworn, B. and Herstatt, C. *Modelle des Innovationsprozesses*, Working paper no. 6, Hamburg University of Technology, 2000.

WEF (2007): *The Global Competitiveness Report 2007-2008,* World Economic Forum, Hampshire: Palgrave.

World Bank (2007): *Will $500 billion close India's infrastructure deficit?*, World Bank India Newsletter, November 2007.

Wyke, A., Mulder, J., and Go, R. (2006): *The future of the life sciences industries: Strategies for Success in 2015*, Deloitte white paper.

Yim, D.S., and Nath, P. (2005): "National Innovation Systems in the Asian Context", in: *Science Technology & Society*, Vol. 10, No. 1, 1-10.

Appendix 1: List of Interviewed Institutions

No.	Institution of the survey participant(s)	Persons interviewed
1	Council of Scientific and Industrial Research (CSIR) – Human Resources Development Centre, Ghaziabad	1
2	Council of Scientific and Industrial Research (CSIR) – National Institute of Science, Technology & Development Studies	4
3	Council of Scientific and Industrial Research (CSIR) – R&D Planning Division, New Delhi	1
4	DFG (Deutsche Forschungsgemeinschaft - German Research Foundation), New Delhi	1
5	EU-India Trade and Investment Development Programme, New Delhi	1
6	Florida International University, Florida (USA)	1
7	Government of Germany, officers stationed at German Embassy in New Delhi and in German Consulate in Mumbai	3
8	Government of India, Department of Science and Technology, New Delhi	4
9	Government of India, Department of Scientific and Industrial Research, New Delhi	3
10	Indian Institute of Technology (IIT), Delhi	1
11	Indian Institute of Technology (IIT), Delhi – Foundation for Innovation & Technology Transfer	1
12	Indian Machine Tool Manufacturers' Association	1
13	Indian Science Writers' Association	1
14	Indo-German Chamber of Commerce, New Delhi	1
15	Indo-German Export Promotion Foundation, Gurgaon / New Delhi	1
16	Institute of Management Technology, Ghaziabad	1
17	National Innovation Foundation, Ahmedabad	1
18	Nova Southern University, Florida (USA)	1
19	Tata Institute of Social Sciences, Mumbai	2
20	UN Asian and Pacific Centre for Transfer of Technology	2
21	VDMA (Verband Deutscher Maschinen- und Anlagenbau - German Engineering Federation), Hamburg (Germany)	1
22	WHU – Otto Beisheim School of Management, Vallendar (Germany)	1
	Total	**34**

Appendix 2: List of Interviewed Firms

No.	Firm of the survey participant(s) (identity concealed)	Persons interviewed
1	A Danish/German IT major, Pune	1
2	A German aerospace engineering services provider, Hamburg	1
3	A German automotive components manufacturer, Bangalore	3
4	A German automotive components manufacturer, NCR Delhi	2
5	A German automotive components manufacturer, Pune	1
6	A German automotive components supplier, NCR Delhi	2
7	A German automotive engineering services provider, Hamburg	1
8	A German automotive engineering services provider, NCR Delhi	2
9	A German biotech services provider, Hamburg (Germany)	1
10	A German conglomerate, Bangalore	1
11	A German electro-acoustic components manufacturer, Pune and Hamburg	2
12	A German engineering services provider, Mumbai	1
13	A German IT solutions provider, Hamburg	1
14	A German IT specialist, NCR Delhi	1
15	A German logistics major, Hamburg	1
16	A German machine manufacturer, Hamburg and Pune	2
17	A German packaging material manufacturer, NCR Delhi	1
18	A German parking and fuelling components manufacturer, Bangalore	1
19	A German pharmaceutical major with R&D center, Mumbai	1
20	A German software major, Bangalore	1
21	A leading international aero plane manufacturer, New Delhi office	1
22	A US automotive engineering services provider, Bangalore office	1
23	A US firm with third party KPO service offers, NCR Delhi	1
24	A US software major, NCR Delhi	1
25	A US-origin, global IT major, Bangalore	2
26	An Indian automotive components manufacturer, Pune	1
27	An Indian chemical firm, NCR Delhi	1
28	An Indian E-Commerce firm, Delhi	1
29	An Indian IT major, Bangalore	2
30	An Indian IT major, Bangalore and Mumbai	2
32	An Indian Mobile Network Operator	1
32	An Indian offshore services consultant, Bangalore	1
33	An Indo-German major in insurance sector, Pune	1
34	An Indo-German offshoring services provider, NCR Delhi	1
35	An international business consultancy firm, Mumbai	1
36	Deutsche Leasing, Bad Homburg* (Jürgen Enzelmüller)	1
37	Hako-Werke International GmbH, Hamburg* (Rüdiger Schröder, MD)	1
38	Research center of a German automotive concern, Bangalore	2
39	Rödl und Partner, Nürnberg* (Harald Kunze)	1
40	Wipro, Munich office* (Christian Kayser)	1
	Total	**51**

* Opinions were expressed in a public discourse and confirmed in a short discussion with one of the authors afterwards.

Appendix 3: India's Premier Education and Research Institutions

No.	**Institutes of National Importance** (sorted alphabetically)	**Year of establishment / recognition**
1	All India Institute of Medical Sciences, New Delhi	1956
2	Dakshina Bharat Hindi Prachar Sabha, Chennai	1964
3	Indian Institute of Technology, Chennai	1959
4	Indian Institute of Technology, Guwahati	1994
5	Indian Institute of Technology, Kanpur	1957
6	Indian Institute of Technology, Kharagpur	1951
7	Indian Institute of Technology, Mumbai	1958
8	Indian Institute of Technology, New Delhi	1961
9	Indian Institute of Technology, Roorkee	2001
10	Indian Statistical Institute, Calcutta	1959
11	National Institute of Pharmaceutical Education & Research, Mohali	1998
12	Post Graduate Institute of Medical Education & Research, Chandigarh	1967
13	Sree Chitra Tirunal Institute of Medical Sciences and Technology, Thiruvananthapuram	1980

Table 10: India's Institutes of National Importance [52]

No.	**Selected Institutions with recognition as "Deemed Universities"** (sorted alphabetically)	**Year of establishment / recognition**
1	Allahabad Agricultural Institute (Uttar Pradesh)	2000
2	Bharati Vidyapeeth (Maharashtra)	1996
3	Birla Institute of Technology & Science (Rajasthan)	1964
4	Homi Bhabha National Institute (Maharshtra)	2005
5	Indian Agricultural Research Institute	1958
6	Indian Institute of Foreign Trade (Delhi)	2002
7	Indian Institute of Science (Karnataka)	1985
8	Indian Veterinary Research Institute (Uttar Pradesh)	1983
9	International Institute of Information Technology (Andhra Pradesh)	2001
10	International Institute of Information Technology (Karnataka)	2005
11	Jawaharlal Nehru Centre for Advanced Scientific Research (Karnataka)	2002
12	Kalinga Institute of Industrial Technology (Orissa)	2002
13	National Brain Research Institute (Haryana)	2002
14	North Eastern Regional Institute of Science & Technology (Arunachal Pradesh)	2005
15	Tata Institute of Fundamental Research (Maharshtra)	2005

Table 11: India's selected deemed universities [53]

[52] Data: UGC 2006b, status: as on 31.03.2006.
[53] Data: UGC 2006b, status: as on 31.03.2006.

No.	**National Institutes of Technology** (recognized under National Institutes of Technology Act, 2007; sorted alphabetically)
1	Dr. B.A. Ambedkar National Institute of Technology, Jalandhar
2	Malviya National Institute of Technology, Jaipur
3	Maulana Azad National Institute of Technology, Bhopal
4	Motilal Nehru National Institute of Technology, Allahabad
5	National Institute of Technology, Agartala
6	National Institute of Technology, Calicut
7	National Institute of Technology, Durgapur
8	National Institute of Technology, Hamirpur
9	National Institute of Technology, Jamshedpur
10	National Institute of Technology, Kurukshetra
11	National Institute of Technology, Patna
12	National Institute of Technology, Raipur
13	National Institute of Technology, Rourkela
14	National Institute of Technology, Silchar
15	National Institute of Technology, Srinagar
16	National Institute of Technology, Surathkal
17	National Institute of Technology, Tiruchirappalli
18	National Institute of Technology, Warangal
19	Sardar Vallabhbhai National Institute of Technology, Surat
20	Visvesvaraya National Institute of Technology, Nagpur

Table 12: India's National Institutes of Technology [54]

No.	**Indian Institutes of Management** (sorted alphabetically)	**Year of establishment**
1	Indian Institutes of Management, Ahmedabad	1961
2	Indian Institutes of Management, Bangalore	1973
3	Indian Institutes of Management, Calcutta	1961
4	Indian Institutes of Management, Indore	1998
5	Indian Institutes of Management, Kozhikode (Calicut)	1996
6	Indian Institutes of Management, Lucknow	1984
7	Indian Institutes of Management, Shillong (first intake: June 2008)	2007

Table 13: Indian Institutes of Management [55]

No.	**Autonomous Institutions under Department of Biotechnology** (sorted alphabetically)
1	Centre for DNA Fingerprinting and Diagnostics (CDFD), Hyderabad
2	Institute of Bioresources and Sustainable Development (IBSD), Imphal
3	Institute of Life Sciences, Bhuvaneswar
4	National Institute of Immunology, New Delhi
5	National Centre for Plant Genome Research (NCPGR), New Delhi
6	National Brain Research Centre (NBRC), Gurgaon
7	National Centre for Cell Sciences, Pune

Table 14: Institutions of Department of Biotechnology [56]

[54] Status: as on 15.08.2007. 17 of them were earlier known as "Regional Institutes of Technology"
[55] Source: Information on respective websites, retrieved: 05.01.2008.

No.	**Affiliate Institutes of Council of Scientific and Industrial Research** (sorted alphabetically)
1	CSIR Headquarters, New Delhi
2	Advanced Materials and Processes Research Institute (AMPRI), Bhopal
3	Central Building Research Institute, Roorkee
4	Central Drug Research Institute, Lucknow
5	Central Electrochemical Research Institute, Karaikudi
6	Central Electronics Engineering Research Institute, Pilani
7	Central Food Technological Research Institute, Mysore
8	Central Glass & Ceramic Research Institute, Kolkata
9	Central Institute of Medicinal & Aromatic Plants, Lucknow
10	Central Institute of Mining and Fuel Research, Dhanbad (CFRI Campus)
11	Central Institute of Mining and Fuel Research, Dhanbad (CMRI Campus)
12	Central Leather Research Institute, Chennai
13	Central Mechanical Engineering Research Institute, Durgapur
14	Central Road Research Institute, New Delhi
15	Central Salt & Marine Chemicals Research Institute, Bhavnagar
16	Central Scientific Instruments Organisation, Chandigarh
17	Centre for Cellular & Molecular Biology, Hyderabad
18	CSIR Centre for Mathematical Modelling & Computer Simulation, Bangalore
19	CSIR Madras Complex, Chennai
20	CSIR Unit for Research and Development of Information Products, Pune
21	Indian Institute of Chemical Biology, Kolkata
22	Indian Institute of Chemical Technology, Hyderabad
23	Indian Institute of Integrative Medicine(IIIM), Jammu
24	Indian Institute of Petroleum, Dehradun
25	Industrial Toxicology Research Centre, Lucknow
26	Institute of Genomics and Integrative Biology, Delhi
27	Institute of Himalayan Bioresource Technology, Palampur
28	Institute of Microbial Technology, Chandigarh
29	Institute of Minerals and Materials Technology (IMMT), Bhubaneswar
30	National Aerospace Laboratories, Bangalore
31	National Botanical Research Institute, Lucknow
32	National Chemical Laboratory, Pune
33	National Environmental Engineering Research Institute, Nagpur
34	National Geophysical Research Institute, Hyderabad
35	National Institute for Interdisciplinary Science & Technology, Thiruvananthapuram
36	National Institute of Oceanography, Goa
37	National Institute of Science Communication and Information Resources, New Delhi
38	National Institute of Science, Technology and Development Studies, New Delhi
39	National Metallurgical Laboratory, Jamshedpur
40	National Physical Laboratory, New Delhi
41	North - East Institute of Science and Technology, Jorhat
42	Structural Engineering Research Centre, Chennai

Table 15: Institutes under CSIR affiliation [57]

[56] Source: Information on DBT website, retrieved: 05.01.2008.
[57] Source: Information on CSIR website, retrieved: 05.01.2008.

Appendix 4: Questionnaire

Research Project Global Innovation
Hamburg University of Technology (TUHH)
Institute of Technology & Innovation Management
Schwarzenbergstr. 95, D-21073 Hamburg, Germany
www.global-innovation.net / www.tuhh.de/tim

Research Project Global Innovation (RPGI) is an initiative of the Institute of Technology & Innovation Management (TIM) at Hamburg University of Technology (TUHH), Germany. A primary objective of this project is to observe, analyze and forecast developments in the field of globalization of innovation. It further aims to provide decision-makers from selected industry sectors with useful insights while deciding on whether or not to internationalize their innovation / R&D activities, e.g. to India. Apart from this strategic perspective we intend to identify necessary organizational- and process-related changes that eventually need to be mastered.
For this purpose, we are conducting a study of international firms engaged in innovation / R&D activities in India. We kindly ask you to give us the opportunity for a personal interview with senior level managers responsible for corporate strategy and R&D. The data will be evaluated anonymously and all participants provided with the results.

Contact Details			
Firm			
Interview partner			
Position			
Address			
Telephone			
E-Mail			
Conducted by:		On:	Place:

1. General firm-specific data	
Are you a part of an international group?	
How long have you been active in India?	
How many locations do you have in India?	
Annual turnover in India	
Annual, global turnover	
Which industry are you active in?	

1.1 Which activities are conducted by the local unit?			
R&D	**Production**	**Marketing & Sales**	**Others**
☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No
Since:	Since:	Since:	Since:
Employees Then:	Employees Then:	Employees Then:	Employees Then:
Employees Today:	Employees Today:	Employees Today:	Employees Today:
Business Expenditure on R&D (BERD) and its share in total expenditure:			

1.2 Which factors played a crucial role while selecting the location (India/city)?
(For instance, lower costs, participating in clusters, proximity to cooperation partners, proximity to production facilities, availability of skilled labour, etc.)

1.3 How did you select the location? Who was involved in the decision-making?
(For instance business consultants etc.)

1.4 What is the skill base of the firm in India? Percentage of employees having:	
Ph.D.	
Bachelor or Master of Technology	
Bachelor or Master of other disciplines	
Technical Diploma holders	
Others (please specify)	

1.5 If you do R&D, please specify the type of R&D undertaken!		
Type of work	**For (internal) corporate use**	**Service for (external) customers (contract R&D)**
Basic Research		
Applied Research		
Product Development		
Process Development		
Others (please specify)		

2. What is/was the role of the Indian unit within the overall innovation strategy of your firm? (Please put a cross in the respective columns.)			
Role	Initially	Currently	Vision (in 5 years)
Local Adaptor * Adjustments to customer-specifications on existing products originally conceptualized and developed elsewhere	☐ N ☐ O ☐ P	☐ N ☐ O ☐ P	☐ O ☐ P
In-house Contractor * Executes individual tasks of the development process according to specifications set by the project leader (e.g. headquarters)	☐ N ☐ O ☐ P	☐ N ☐ O ☐ P	☐ O ☐ P
Product Developer for local market ("Local Developer") * Conceptualizes and develops own innovation ideas (products, processes and services) for the local market. The unit is responsible for project and budgetary planning.	☐ N ☐ O ☐ P	☐ N ☐ O ☐ P	☐ O ☐ P
Product Developer for global market ("Global Developer")* Conceptualizes and develops own innovation ideas (products, processes and services) for the global market. The unit is responsible for project and budgetary planning.	☐ N ☐ O ☐ P	☐ N ☐ O ☐ P	☐ O ☐ P
Legend: N = Never, O = Occasionally, P = Predominantly			

* To be considered: Different business units

2.1 Reasons for these developments: (Vision, strategic objectives, planned investments in HR, machines etc., changes in importance vis-à-vis the R&D unit at headquarters?)
-- -- -- -- -- --

2.2 Information on R&D Output		
Output indicator	**Last year**	**In past 3 years**
Patents filed		
Patents granted		
Copyrights obtained		
New products developed		
New processes developed		
Design prototypes developed		
Components developed on contract basis		
Others (please specify)		

3. What are your motives of doing research and/or development work in India? Has there been a shift in the motives? (Scale 1 = very strong motive; 5 = weak motive)			
Motive	Initially	Currently	Vision (in 5 years)

4. Regarding your company how do you evaluate following aspects of doing research and/or development work in India?						
	1 = no problem at all					6 = severe problem
Finding qualified personnel:						
of Science and Technology disciplines	☐1	☐2	☐3	☐4	☐5	☐6
Management	☐1	☐2	☐3	☐4	☐5	☐6
Others (please specify)	☐1	☐2	☐3	☐4	☐5	☐6
Quality of education in general	☐1	☐2	☐3	☐4	☐5	☐6
Quality of university education in Science and Technology	☐1	☐2	☐3	☐4	☐5	☐6
Quality of university education in other disciplines	☐1	☐2	☐3	☐4	☐5	☐6
High fluctuation rate (job hopping)	☐1	☐2	☐3	☐4	☐5	☐6
Increasing labour costs	☐1	☐2	☐3	☐4	☐5	☐6
Concerns regarding loosing internal know-how	☐1	☐2	☐3	☐4	☐5	☐6
Enforcing intellectual property rights	☐1	☐2	☐3	☐4	☐5	☐6
Enforceability of contracts	☐1	☐2	☐3	☐4	☐5	☐6
General infrastructure (e.g. telecommunication and power supply)	☐1	☐2	☐3	☐4	☐5	☐6
Infrastructure related to high-tech	☐1	☐2	☐3	☐4	☐5	☐6
Bureaucratic hurdles (please specify)	☐1	☐2	☐3	☐4	☐5	☐6
Legal hurdles, e.g. prohibition of certain R&D (please specify)	☐1	☐2	☐3	☐4	☐5	☐6
Others (please specify)	☐1	☐2	☐3	☐4	☐5	☐6

5. How has the skill-profile of your employees changed in past 3 years? (For instance greater number of engineers than earlier, or more management degree-holders, or more non-university diploma holders etc)
-- -- --

5.1 Did you experience any difficulties in hiring qualified personnel in past 3 years?	☐ Yes ☐ No

If yes, please specify		
	With work experience	**Trainees**
Engineers	☐	☐
Science and Technology graduates	☐	☐
Technicians / skilled workers without university degree	☐	☐
Managers	☐	☐
Others (please specify) ……………………………………….	☐	☐

6. How intensive is the interaction between the Indian R&D unit and the central R&D unit at headquarters?
☐ Very intensive ☐ Intensive ☐ Regular ☐ Occasional ☐ None

6.1 How do you ensure successful cooperation between the Indian R&D unit and the central R&D unit at headquarters (e.g. regular exchanges of R&D personnel / how often)?

6.2 Does interaction with the central R&D unit cause frictions?
☐ Yes ☐ No ☐ Occasionally

6.3 Organisational aspects: Questions regarding In-house cooperation and knowledge-transfer between the Indian unit and headquarters		
	1 = no problem at all	6 = severe problem
Acceptance at the central R&D unit	☐1 ☐2 ☐3	☐4 ☐5 ☐6
Knowledge-sharing	☐1 ☐2 ☐3	☐4 ☐5 ☐6
Cross-cultural differences	☐1 ☐2 ☐3	☐4 ☐5 ☐6
Language barriers	☐1 ☐2 ☐3	☐4 ☐5 ☐6
Time-zone differences	☐1 ☐2 ☐3	☐4 ☐5 ☐6
Reporting obligations	☐1 ☐2 ☐3	☐4 ☐5 ☐6
Organisational flexibility	☐1 ☐2 ☐3	☐4 ☐5 ☐6
Project coordination	☐1 ☐2 ☐3	☐4 ☐5 ☐6
Others (please specify) ……………………………………...............	☐1 ☐2 ☐3	☐4 ☐5 ☐6

----

7. Do you hire external contractors to conduct parts of your R&D? (Outsourcing)	☐ yes ☐ no

7.1 Do you cooperate with external partners in R&D? (Joint R&D projects)	☐ yes ☐ no

	Partners					
	Customers	Suppliers	Universities	Specialised Research Institutions	Competitors	Others (Please specify)
Partners in India	☐	☐	☐	☐	☐	☐
International Partners	☐	☐	☐	☐	☐	☐

7.2.1 What are the reasons for your collaboration with the earlier mentioned external partners in India?

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

7.3 Is cooperation gaining importance for you in the field of R&D? ☐ Yes ☐ No

How many R&D projects have you completed in collaboration? ……………………
How many R&D projects are currently underway in collaboration? …………………
Are you satisfied with the results of such R&D projects in collaboration? ☐ Yes ☐ No

7.4 Based on your experiences, which factors inhibit or prevent collaboration with (potential) partners in India?

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

7.5 Do you participate in local/regional business and/or research networks in India? If yes, in which way? (For instance associations etc.)
-- -- -- --