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Trends in Public and Private Investments in ICT R&D in India

Authors: Payal Malik and P. Vigneswara Ilavarasan
Editors: Marc Bogdanowicz and Renata Jaksa

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Contact information
Address: Edificio Expo. c/ Inca Garcilaso, 3. E-41092 Seville (Spain)
E-mail: jrc-ipts-secretariat@ec.europa.eu
Tel.: +34 954488318
Fax: +34 954488300

http://ipts.jrc.ec.europa.eu/
http://www.jrc.ec.europa.eu/

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PREFACE

R&D activity in the Information and Communication Technologies (ICT) industrial sectors is an important factor in boosting the competitiveness of the European economy. The ICT industry and ICT-enabled innovation in non-ICT industries and services is making an increasingly important contribution to economic growth in advanced economies. The ICT sector was highlighted in the EU Lisbon Objectives, and has retained its prominence in the recently proposed **Europe 2020 Strategy**.

The Information Society Unit at IPTS[1] is carrying out a research project on Prospective Insights on R&D in ICT (PREDICT)[2] and has produced a series of annual reports.[3] PREDICT combines, in a unique way, three complementary perspectives: national statistics (covering both private and public R&D expenditures), company data, and technology-based indicators. PREDICT relies on the latest available official statistics delivered by Member States, Eurostat and the OECD.

The first part of each annual PREDICT report gathers the most recent quantitative information on ICT R&D investments in the EU and worldwide. It presents the data by countries, sub-sectors and companies. The second part of each report is dedicated to a specific thematic analysis. In 2009, the thematic analysis focused on patents data analysis. In 2010, it focuses on internationalisation of ICT R&D.

As an extension of these existing research efforts, IPTS launched a tender for research focused on R&D in ICT sectors in India, China and Taiwan, in order to gain a better understanding of major ICT R&D capabilities in those parts of the world. The 2011 PREDICT report offers a country-level approach to ICT R&D internationalisation by analysing the ICT industry in China and India, the two largest emerging economies. It then provides a first synthesis of the research.[4]

This research exercise led to three further reports on China, India and Taiwan, each one including a dataset and a technical annex. These reports have been written by national experts under the coordination of the International Centre for Economic Growth (ICEG, Hungary).

Tribute to Pál Gáspár

Pál Gáspár was the founding Director of the International Centre for Economic Growth (ICEG European Centre). He and his team of researchers have collaborated with IPTS on numerous successful research projects and he was a project leader for the overall study of which this report is a part.

We would like to acknowledge his invaluable contribution to this project. His professionalism will be greatly missed. He was an enlightened economist, a fascinating Professor and a creative Director. For us, however, his values, attitude to life, and openness made him, first and foremost, a friend.

Marc Bogdanowicz
Information Society Unit, IPTS

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1 IPTS (the Institute for Prospective Technological Studies) is one of the 7 research institutes of the European Commission's Joint Research Centre.

2 PREDICT is co-financed by JRC-IPTS and the Information Society & Media Directorate General of the European Commission.

3 Available on our website under the link http://is.jrc.es/pages/ISG/PREDICT.html

4 Also based on these country reports and further research, IPTS is preparing a report on ICT in BRIC countries. For more, see under Simon J-P (2011) (forthcoming).

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ADC	Automated Distribution Centre
AMR	Adaptive Multi-rate
ASSOCHAM	Associated Chambers of Commerce and Industry of India
BEL	Bharat Electronics Ltd.
BOP	Bottom Of the Pyramid
BPO	Business Process Outsourcing
CAGR	Compound Annual Growth Rate
C-DAC	Centre for Development of Advanced Computing
C-DOT	Centre of Development of Telematics
CMM	Capability Maturity Model
CPP	Calling Party Pays
CSIR	Council of Scientific and Industrial Research
CSO	Central Statistical Organisation
CSS	Computer Services and Software
DIT	Department of Information Technology
DST	Department of Science & Technology
EBITDA	Earning Before Interest, Tax, Depreciation and Amortisation
ECIL	Electronics Corporation of India Ltd.
EIU	Economist Intelligence Unit
EMH	Emerging Market Handset
ESC	Electronics and Software Promotion Council
FDI	Foreign Direct Investment
FERA	Foreign Exchange Regulations Act
FNS	Financial Network Services
GoI	Government of India
HQ	Head Quarter
HSPA	High Speed Packet Access
ICT	Information and Communication Technology
IIT	Indian Institute of Technology
IMT-A	Mobile Telecommunications-Advance
ITES	Information Technology enabled services
ITI	Indian Telephone Industries
MHRD	Ministry of Human Resources Development
MNCs	Multinational Companies
MOSPI	Ministry of Statistics & Programme Implementation
MoU	Minutes of Usage
NACE	Statistical Classification of Economic Activities in the European Community
NASSCOM	National Associational for Software and Services Companies
NCR	National Capital Region
NGN	Next Generation Network
NIC	National Industrial Classification
NIIT	National Institute of Information Technology
NIP	New Industrial Policy
NSTMIS	National Science and Technical Manpower Systems unit
NTP	National Telecom Policy
OEM	Original Equipment Manufacturers
PPP	Public-Private Partnership

PPP	Purchasing Power Parity
R&D	Research & Development
SME	Small and Medium Enterprises
STPI	Software Technology Parks of India
TCO	Total Cost of Ownership
TCoE	Telecom Centres of Excellence
TCS	Tata Consultancy Services
TI	Texas Instruments
TI	Texas Instruments
TIFAC	Technology Information and Forecasting Assessment Council
TNCs	Transnational Corporations
VC	Venture Capital
WTO	World Trade Organisation

EXECUTIVE SUMMARY

The Indian Information Communication Technology (ICT) industry is contributing to the national economy in many ways and almost all states in India are targeting the sector as a vehicle for economic development. NASSCOM's 2009 strategic report estimates that the Indian IT-BPO (Business Process Outsourcing) industry achieved revenues of USD 71.7 billion in FY2009, of which the IT software and services industry accounted for USD 60 billion. Direct employment at the end of March 2009 was expected to reach nearly 2.23 million, while indirect job creation was estimated to touch 8 million. The sector's revenues grew from 1.2% of national GDP in FY1998 to an estimated 5.8% in FY2009. The net value added by this sector to the economy was estimated at 3.5-4.1% for FY2009.

The Indian ICT sector has evolved in three phases: up to 1984, 1984–1990 and post-1990. In the first phase, apart from trying to establish its own technological trajectories, the state attempted to run the industry which resulted in no commercial sector. In this phase, there was no great differentiation between software and hardware. In the second phase, the government realized that software was a viable option for income generation and technological capability enhancement. In the third phase, the software export industry blossomed, aggressively promoted by both national and sub-national governments. Consequently, the export-driven growth model ignored the hardware sector and domestic sector, despite their huge potential. Though the ICT sector is growing in all domains, it is predominantly driven by software services and telecom services.

Until the 1990s, the Indian economy was under state control and there was little incentive for private industry to invest in R&D. The Indian ICT sector is dominated by the larger players with the top 200 firms contributing about 86% of the total revenues in 2008. Multinational firms dominate in the innovation space through their Indian R&D centres. Although larger Indian firms perform R&D activities, they are sub-contractors and do not have ownership of their activities. An analysis of secondary data showed that most of the multinational firms follow the conventional outsourcing model: they enter India as a cost centre which then evolves into a technology centre.

At present, the ICT sector is clustered in six cities: Bangalore, Pune, Chennai, Hyderabad, the National Capital Region (Noida, Delhi and Gurgaon) and Mumbai. However, efforts are being made by the central and state governments to spread the sector to second-tier cities. A comparison of the major ICT clusters shows that the Bangalore cluster presents a more mature eco-system for the ICT industry compared to the other clusters. Due to its historical lead advantages, it has a deep labour market, proximity to well-known research institutes, government research labs, the presence of venture capital, and a healthy mix of large domestic firms, multinationals and other supplementary firms.

Hardware manufacturing is weak with some innovation happening in semiconductor design and manufacturing. Poor manufacturing capabilities and lack of adequate support infrastructure will continue to put the Indian ICT industry at a disadvantage to competitive producers like China, Taiwan and Korea.

University-industry alliances are much to be desired, but they are limited to campus placement and student internships. The labour pool with engineering or ICT-related education is impressive in terms of numbers, but a closer look reveals a poor research component.

Though Indian firms are expanding their global reach and technology domains in service through acquisitions, it is difficult to conclude that R&D capabilities have been acquired. Indian firms continue to cater to western clients through software product development or engineering services, and they innovate for in-house consumption rather than developing off-the-shelf products for the open market.

Since the Indian ICT sector concentrates on services, innovation is predominantly on processes. This service innovation can be observed in other areas:

- Transition from on-site to off-shore, by sending people for project execution at the client's site to executing and managing projects in India;
- Productised services, in which Indian firms standardise the services provided to clients and sell them as productised services, a level below off-the-shelf products;
- Virtual extension, in which Indian firms serve as sub-contractors but interact with primary clients directly;
- Human capital capacity building, because though human capital is available, skill gaps are met by the sector itself.
- Finally, service process innovation is crucial in explaining the success of the Indian telecom sector. Tailored tariff packages in line with the affordability profiles of Indians and also outsourced network expansion were the first of their kind and have yet to become a global trend.

INDIA COUNTRY PROFILE

India is a federal republic with a three-tier governance structure at centre, state and local levels. The executive power is concentrated in Parliament with the upper house – Rajya Sabha (Council of States) – appointed by the President and elected by state and territory assemblies, and the lower house– Lok Sabha (House of the People) – popularly elected by 354 million voters, with some 14,700 candidates and more than 500 parties.

For most of its post-independence history, India adopted a Fabian socialist approach to the organisation of the economy with strict government control over domestic and foreign investment in an almost-closed economic framework. The end of planned economic development in 1991 led to across-the-board policy changes, the most important of which was the liberalisation of industrial policy with a State commitment to introduce competition in some industries that had been previously served by government-owned monopolies.

With an estimated population of 1,138 million, India is the world's second most populous country. According to India's 2001 population census, almost 70% of Indians reside in rural areas, although in recent decades migration to larger cities has led to an increase in the country's urban population. India's literacy rate is 64.8% (53.7% for females and 75.3% for males). The national gender ratio is 944 females per 1,000 males. India's median age is 24.9 and the population growth rate is 1.38% per annum.

With a GDP[5] growth rate of 9.01% in 2007-08, the economy is among the fastest growing in the world. India's GDP, in terms of USD exchange rate, was USD 777.74 billion in 2007–08. When measured in terms of purchasing power parity (PPP), India has the world's third largest GDP at USD 4.164 trillion. India's per capita income (nominal) was USD 680 in 2007–08, while its per capita (PPP) was USD 3,600.

India's demographic profile, with about 54% of the population under 25, offers favourable prospects for rapid economic growth for several decades ahead, which is not the case for the most advanced industrial economies or for China.

Table 1: India Country Profile

Item	India
GDP at factor cost (USD billion) at 1999–00 prices	777.74 (for 2007–08) #@
GDP at factor cost (USD billion) at current prices	1073.75 (for 2007–08) #@
Per capita GNP at factor cost (USD) at 1999–00 prices	680.18 (for 2007–08) #@
GDP at factor cost 1990-91–2007-08% at 1999–00 prices	6.07 (CAGR) #
Population (million)	1138 (for 2007–08)#

Note: #: Source - National Account Statistics Reports – 2009 and 1980-81–1992-93.

@: Exchange rate: Rs. 40.2410/US$ 1 (Average exchange rate for 2007–08).

India's sectoral GDP composition is presented in Table 2. The services sector has been the main driving force in the growth of the Indian economy, contributing 55.73% to the total GDP in 2007-08.[6] It is expected that services will play a major role in India's growth in the future as well. Agriculture and allied activities and manufacturing, with 17.80% and 15.22%

[5] GDP at factor cost (at 1999-2000 prices).

[6] The services sector according to the official data comprises Trade, hotels & restaurants, Financing, insurance, real estate & business services, Community, social & personal services, Transport, storage & communication which add up to 55.73% for the year 2007-08.

shares in total GDP respectively, are the other major contributors. However, the share of the manufacturing sector has not changed much between 2000-01 and 2007-08.

Table 2: Sectoral contribution to the GDP at factor cost (in %)

Industry	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08
Agriculture, forestry & fishing	23.89	23.99	21.43	21.72	20.22	19.54	18.51	17.80
Trade, hotels & restaurants	14.34	14.86	15.29	15.51	15.54	15.64	15.74	15.90
Manufacturing	15.26	14.79	15.22	14.95	15.12	15.05	15.33	15.22
Financing, insurance, real estate & business services	13.04	13.22	13.75	13.37	13.52	13.76	14.26	14.62
Community, social & personal services	14.98	14.74	14.75	14.33	14.24	13.93	13.41	13.14
Transport, storage & communication	7.96	8.15	8.96	9.52	10.24	10.75	11.39	12.07
Construction	5.81	5.71	5.94	6.13	6.62	7.03	7.16	7.23
Electricity, gas & water supply	2.44	2.34	2.36	2.28	2.29	2.20	2.11	2.04
Mining & quarrying	2.28	2.20	2.30	2.19	2.20	2.11	2.09	1.98

Source: Central Statistical Organisation, National Account Statistics, 2008 and 2009, Statement 10: Gross Domestic Product by Economic Activity.
Note: All figures are calculated using GDP at factor cost at 1999-2000 prices.

Engineering goods contribute most to exports, followed by petroleum and chemicals and related products. The US, UAE and China are India's top three export markets. Petroleum, crude and products were responsible for 31.6% of total imports in India in 2007-08, followed by electronic goods and transport equipment with 8.2% and 8% shares in total imports respectively. Table 3 gives further details on India's foreign trade.

Table 3: India's exports and imports

Major exported commodities	2007-08	Major Imported commodities	2007-08
Year/ Commodity	% of total	Year/ Commodity	% of total
Engineering Goods	22.9	Petroleum, Crude and Products	31.6
Petroleum Products	17.4	Electronic Goods	8.2
Chemicals and Related Products	13.0	Transport Equipment	8.0
Gems and Jewellery	12.1	Machinery except Electrical and Electronic	7.9
Textile and Textile Products	11.9	Organic and Inorganic Chemicals	3.9
Major Markets	**% of total**	**Major Suppliers**	**% of total**
U.S.A	12.70	China	10.77
U.A.E.	9.58	U.S.A	8.35
China	6.64	Saudi Arabia	7.71
Singapore	4.52	U.A.E.	5.35
U.K.	4.11	Iran	4.34

Source: Handbook of Statistics on Indian Economy, 2008-09, Reserve Bank of India.

In 2007-08, India's non-oil exports (commodities) stood at USD 136.228 billion, whereas 'invisible' exports (services) were USD 148.604 billion. This macro picture reveals the

importance of the services sector in the Indian economy. The ICT sector mirrors this as it is dominated by the services sector, with manufacturing forming a very small proportion of the sector. It is in this context that ICT R&D, internationalisation of ICTs and the ICT innovation system have to be situated.

1. DESCRIPTIVE PRESENTATION OF THE ICT SECTOR

Information and Communication Technology (ICT) is an important emerging sector of contemporary India. It contributes to change at various levels –social, political and economic. ICT has brought rural areas much closer to the markets and has improved business transactions. There has been an increased flow of information, thereby increasing productivity and innovation. There has also been an increase in the monitoring and accountability of governments through the use of ICT services.

The success of the Indian ICT industry is being imitated by many developing countries (Carmel, 2003; Heeks and Nicholson, 2002) as a tool for national development. However, access to detailed data on the Indian ICT industry is limited for the researchers. A source of data often repeated in the extant literature is the National Association for Software and Services Companies (NASSCOM). Firm-level data in the NASSCOM annual directories are not available beyond 2003. NASSCOM provides only aggregate data broken down into limited detail. The extant statistical framework of the government is either outdated or inadequate to fully capture the ICT economy (for details, see Chandrasekhar and Ghosh, 2008).

Researchers (for instance, Chandrasekhar and Ghosh, 2008; Parthasarathi and Joseph, 2002) have repeatedly requested adequate data for policy analysis of the industry. Though NASSCOM is quite successful in branding the Indian ICT sector abroad and is serving as a major contact point for foreign investors and prospects, minimal efforts have been made to provide access to data.

The NASSCOM data is not official data and does not follow any industrial classification system. Thus, when reporting their data, they club ICT together with the BPO (Business Process Outsourcing) industry, also known as ITES (IT-enabled services). This data does not represent the ICT sector as defined internationally. Most of the studies on the Indian ICT industry rely on NASSCOM data which does not reveal firm-level information. Nevertheless, as government data is available only for the period, 2000-2004, we need to use the NASSCOM data for the later years to analyse the industry as a whole.

Given the limited detail on the industry sub-sectors, proxy measures are used by this project to understand the contribution made by the sub-sectors (refer to the Technical Annex to the Database). Hence, it is not feasible to discuss sub-sector differences in the analysis. Also, existing academic research presents discussion on the industry in general and does not deal with sub-sector contributions.

1.1 Indian ICT sector

The Indian ICT industry contributes to the national economy in many ways and almost all states in India are targeting the ICT sector as a vehicle for economic development. According to the NASSCOM strategic report for 2009, the Indian IT-BPO industry is estimated to achieve revenues of USD 71.7 billion in the financial year (FY) 2009, with the IT software and services industry accounting for USD 60 billion of revenues. Direct employment at the end of March 2009 was expected to reach nearly 2.23 million, while indirect job creation was estimated to touch 8 million. As a proportion of national GDP, the sector revenues grew from

1.2% in FY1998 to an estimated 5.8% in FY2009. The net value added by this sector to the economy was estimated at 3.5-4.1% for FY2009.

Most of the indirect employment absorbs the unemployed who are school-leavers, either with or without a school diploma. The revenue generated by the industry is also a driving factor for many other sectors in the country, especially real estate and retail. Apart from direct employment, the ICT sector is credited with creating the first generation of entrepreneurs and the growth of the venture capital industry in India. The concept of Employee Stock Options was introduced by this sector. The success of the sector has built confidence in foreign customers who are outsourcing projects in other industrial domains as well (see for instance, the growth of the bio-technology industry). Also, the increase in outsourcing of high-end research and development projects is due to the proven delivery capabilities of the Indian ICT firms, which lead to skill diffusion of core areas. Also, employment opportunities for women, especially unmarried young graduates in BPO, have increased, amounting to 45% of the employment. This was possible due to the quality assurance provided by the firms through globally recognised quality certificates like the capability maturity model (CMM) and ISO series. The largest number of CMM-certified firms is located in India, i.e., 58 out of 198. The corporate social responsibilities of the leading firms are quite significant in the areas of education, health and the environment. For instance, Wipro's initiatives reach out to around 500,000 children and 9,698 teachers in 1,065 schools (NASSCOM, 2008).

However, there are concerns about the Indian ICT industry. Some studies point out that resources like manpower are over-directed towards the ICT sector, risking the future of other industrial domains including teaching/training (Joseph, 2002), apart from creating disparities at the societal level. Some studies (for instance, Ilavarasan, 2007) show that the benefits emerging out of the industry are accrued by elite social groups, and the Indian ICT sector serves as export enclaves where no great knowledge diffusion occurs (D'Costa, 2003). In a few instances, political parties supposedly lost their re-election due to their pro-IT policy initiatives which were perceived as neglecting the dominant group, namely, rural people (Ilavarasan, 2007).

The manufacturing and services divisions of the Indian ICT sector have two growth trajectories. The services sector, composed of computer-related services and telecommunications, has been growing at a steady rate compared to the manufacturing sector. India has adopted a 'walking on one leg' strategy in the ICT sector, concentrating more on services exports than on manufacturing (Heeks, 1998; Schware, 1992). According to the Department of IT Electronics, hardware production increased from Rs. 438 billion in 2003-04 to an estimated Rs. 946.9 billion in 2008-09, with a compound annual growth rate (CAGR) of 16.6%. On the other hand, the computer software industry which was worth Rs. 744.9 billion in 2003-04 achieved a production of Rs. 2735.3 billion during the year 2008-09, with a compound annual growth rate of 24.21%.

The story of the Indian ICT sector is centred around IT service exports, which have been growing steadily, from USD 7.3 billion in 2003-04 to USD 23.10 billion in 2007-08. It is estimated that ICT exports will grow to USD 26.91 billion in 2008-09. In percentage to total ICT industry, the contribution of the domestic sector has decreased from 35.11% in 2004-05 to 33.89% in 2008-09, suggesting an increasing contribution from exports. Within the domestic sector, the focus has been more on hardware, which increased from USD 5.1 billion in 2004-05 to USD 11.81 billion in 2008-09.

Table 4: Highlights of the IT-BPO sector performance

S. No.	USD billion	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09E
1	**IT Services**	**10.40**	**13.50**	**17.78**	**23.38**	**30.98**	**35.23**
2	Exports	7.30	10.00	13.31	17.85	23.10	26.91
3	Domestic	3.10	3.50	4.48	5.53	7.88	8.32
4	**BPO**	**3.40**	**5.20**	**7.21**	**9.51**	**12.51**	**14.78**
5	Exports	3.10	4.60	6.30	8.41	10.93	12.84
6	Domestic	0.30	0.60	0.91	1.10	1.58	1.94
7	**Software Products and Engineering Services**	**2.90**	**3.80**	**5.33**	**6.54**	**8.63**	**9.55**
8	Exports	2.50	3.10	4.00	4.94	6.40	7.29
9	Domestic	0.40	0.70	1.33	1.60	2.23	2.26
10	**Hardware**	**5.00**	**5.60**	**7.08**	**8.46**	**12.00**	**12.11**
11	Exports	n.a.	0.50	0.58	0.48	0.50	0.30
12	Domestic	n.a.	5.10	6.50	7.98	11.50	11.81
13	**Total (1+4+7+10)**	**21.60**	**28.20**	**37.41**	**47.83**	**64.12**	**71.67**
14	Exports (2+5+8+11)	12.90	18.20	24.19	31.62	40.88	47.34
15	Domestic (3+6+9+12)	3.80	9.90	13.22	16.21	23.19	24.33

Source: The IT-BPO sector in India, Strategic Review, NASSCOM, 2008 and 2009.
Note: Estimated.

As evident from Table 4, details on the sub-sectors are not available from NASSCOM. We attempted to analyse the sub-sector contributions by sieving the data from government sources. As mentioned earlier, data are available only for the years 2000-2004 (Table 5).

Table 5: Value added of ICT manufacturing and services sub-sectors (Value added in Rs. million at current prices)

NACE categories relating to ICT NIC 2004	2000-01		2001-02		2002-03		2003-04		2004-05	
	Value Added	% of GDP	Value Added	% of GDP	Value Added	% of GDP	Value Added	% of GDP	Value Added	% of GDP
Manufacturing										
3000 Manufacture of office, accounting and computing machinery	8250.2	0.043	9810.32	0.047	12250.7	0.054	16110.96	0.063	10900.89	0.038
3130 Manufacture of insulated wire and cable	10730.64	0.056	9070.02	0.043	5310.34	0.023	5340.41	0.021	6610.61	0.023
3210 Manufacture of electronic valves and tubes and other electronic components	12630.62	0.066	14540.46	0.069	15520.5	0.069	15470.31	0.061	14830.6	0.052
3220 Manufacture of television and radio transmitters and apparatus for line telephony and line telegraphy	5570.72	0.029	7150.02	0.034	7700.15	0.034	6250.83	0.025	9550.85	0.033
3230 Manufacture of television and radio receivers, sound or video recording or reproducing apparatus, and associated goods	13070.56	0.068	11260.98	0.054	17770.86	0.078	14890.79	0.058	12840.6	0.045
3312 Manufacture of instruments and appliances for measuring, checking, testing, navigating and other purposes except industrial process control equipment	4110.89	0.021	4480.95	0.021	5360.1	0.024	4230.47	0.017	3460.57	0.012
3313 Manufacture of industrial process control equipment	1150.61	0.006	2210.5	0.011	2880.36	0.013	4020.65	0.016	3930.21	0.014
Services										
5151 Wholesale of computers, computer peripheral equipment and software	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
5152 Wholesale of electronic and telecommunications parts and equipment	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
6420 Telecommunications	253480	1.316	304720	1.451	291420	1.286	358370	1.406	433110	1.517
7123 Renting of office machinery and equipment (including computers)	12710.825	0.066	13150.322	0.063	13780.959	0.061	14470.177	0.057	15020.954	0.053
72 Computer and related activities	233150.35	1.211	288130.8	1.372	348850.89	1.54	456470.97	1.791	583000.78	2.041

Source: *Statistical Abstract India*, various years, Central Statistical Organization, Ministry of Statistics and Programme Implementation (MoSPI), Government of India (GoI).
Notes: Data on renting of office machinery and equipment (7123) is a proxy measure from 'Domestic product from real estate, Ownership of dwellings and business services'.
National Accounts Statistics – Sources and Methods, 2007.

All the data is presented in Indian Rupees (INR) in crores (Crs). Ten million makes one crore (Cr). For better understanding, see the example for the calendar year 2005 as per the Reserve Bank of India, http://www.rbi.org.in/scripts/PublicationsView.aspx?Id=9656, Accessed on 15 Sept. 2008.

	SDR	USD	Pound Sterling	Mark / Euro	Yen
INR	65.1404	44.1000	80.2530	54.8993	. 40
1 Cr	153514.6	226757.4	124605.9	182151.7	249364.1

According to official government data presented in Table 6, the Indian ICT manufacturing sector is smaller than the services sector. In 2000-01, ICT manufacturing contributed to 0.289% of GDP compared to 2.593% by ICT services. Services continued to grow and manufacturing lagged behind. In 2004, manufacturing contributed only 0.217% to the GDP compared to the 3.611% contribution of the services sector.

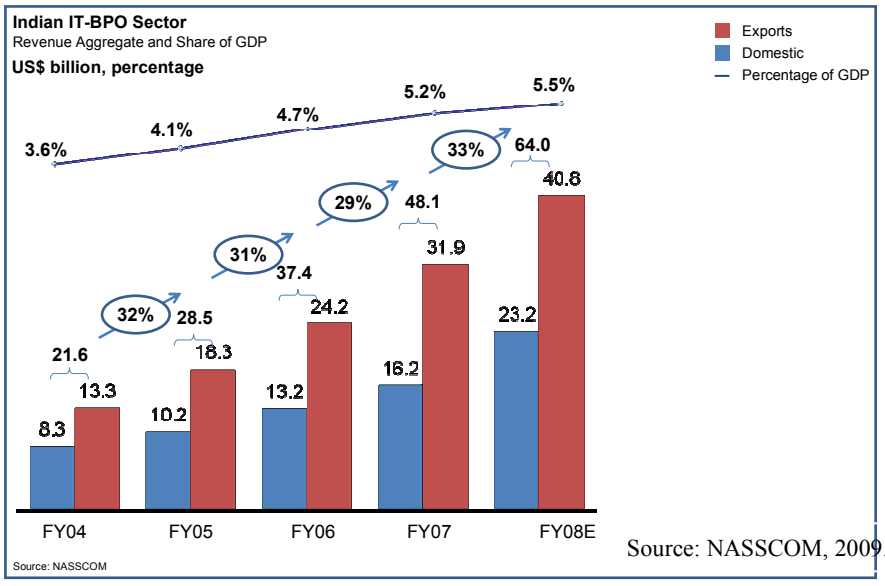
Table 6: Contribution of ICT sector to national growth (Rs. million)

	2000-01		2001-02		2002-03		2003-04		2004-05	
	Value added	% of GDP	Value added	% of GDP	Value added	% of GDP	Value added	% of GDP	Value added	% of GDP
Total ICT sector	554855	2.88	664524	3.16	720845	3.18	895626	3.51	1093256	3.83
ICT manufacturing	55514	0.29	58523	0.28	66793	0.29	66314	0.26	62124	0.22
ICT services	499341	2.59	606001	2.89	654052	2.89	829311	3.25	1031132	3.61

Source: *Statistical Abstract India*, various years, Central Statistical Organization, Ministry of Statistics and Programme Implementation (MoSPI), Government of India (GoI).

In a recent report by NASSCOM (2009), though the breakdown is not available, it is clear that the Indian ICT sector contributed 5.2% to GDP in the year 2006-2007. However, it should be noted that this contribution is of ICT revenue as a proportion of the GDP, while the official data in Table 6 is ICT value-added as a proportion of GDP. Since NASSCOM uses revenue data and not value-added, it is limited.

Figure 1: Growth and contribution of Indian ICT industry



Source: NASSCOM, 2009.

1.2 Indian hardware sector

The strategy of 'walking on one leg' adopted by the Indian ICT sector started in the mid-1990s when India shifted its focus to software from hardware. The Manufacturers' Association for Information Technology opines that the hardware sector was treated with indifference by successive governments (Singh, 2003). From 1991 onwards, the policy orientation changed from an inward-oriented, state directed and controlled development strategy to a liberal economy that opened up to external competition and investment. Various issues with respect to tariff policy, export and import policy, specialised hardware manufacturing hubs, marketing the "Made in India" brand, inviting multinational electronics manufacturing/service companies to set up Indian operations, the development of semiconductor industries, patenting, etc, were taken up in order to bring reforms to this industry (Majumdar, 2010). After the WTO International Trade Agreement, India removed all customs duties on IT hardware by 2004, exposing local manufacturers to global competition. This resulted in consolidation of the sector. Many local manufacturers turned into importers of foreign goods and started serving local demands. India remains a major importer of electronic materials, components and finished equipment that amounted to around USD 20 billion in 2007. The country imports electronic goods mainly from China.

The trend of import-led industrialisation in hardware is being followed in India. During 2001-2007, the production of computers and associated components grew at a compounded annual growth rate of 31%, the highest among electronic products in India. This was followed by communication and broadcast equipment (17%), strategic electronics (21%) and industrial electronics (20%) (IBEF, 2008). The growth in demand for telecom products has been high, with the growing use of mobile phones in India; this is one of the main reasons for the growth in production of electronic goods. Subsectoral analysis is not available, either in the trade press or in the academic literature, owing to lack of differentiated data. However, the analysis of the telecom equipment industry by Mani (2005) offers some insights into how the local manufacturing industry declined despite the technological capabilities of government research labs. Local manufacturers were dependent on the government research lab, the Centre for Development of Telematics (C-DOT), which was working on circuit-switching technology and was oblivious to the emerging packet-switching technology (Mani, 2005; p.4277). As a result, they were unable to handle the open competition after the 1990s.

1.3. ICT services

The services component of ICT is shared by telecommunications and computer-related services. There is no data available on the two sub-sectors, i.e. wholesale of computers, computer peripheral equipment and software, and wholesale of electronic and telecommunications parts and equipment.

1.3.1. Telecommunications services

India faced many challenges in liberalising its telecommunications industry from a monopoly to a decentralised competitive model. During the monopoly era, telephones were not considered a necessity, and, as a result, telephone penetration levels were very low and the quality of service was poor. However, long waiting lists, technological advances and pressure from domestic and international stakeholders pushed the government in the mid-1980s to spread telephone infrastructure.

The results of liberalisation have been impressive. Teledensity has increased from a mere 2% or so in 1999 to around 37% in 2009 and 8-10 million mobile subscribers are added every month. Wireless has been the principal engine for telecom growth in the country. The wireless subscriber base has grown from 0.88 million in 1999 to 391.67 million in 2009. Given that the mobile sector grew at the Compound Annual Growth Rate (CAGR) of 84.01% in the past decade, it will not be difficult to reach a telecom subscriber base of 600 million, as envisaged in the 11th Five-Year Plan.[7]

By March 2007, the stock of capital investment in the telecom sector reached Rs. 2346.87 billion (USD 58.67 billion). The total revenue of the telecom sector in 2008-09 was Rs.1523.60 billion (USD 33 billion[8]) and accounted for 3.09% of the GDP at current prices. The EBITDA of the telecom companies at the end of 2006-07 was Rs.391.67 billion (USD 9.79 billion) and the EBITDA margin was 37%.

[7] The Planning Commission of India is responsible for the creation and execution of India's five-year plans. Currently, the Eleventh Five-Year Plan (2007-2012) is in progress. (For more information see: www.planningcommission.nic.in).

[8] Exchange rate: Rs. 45.917/US$1, average exchange rate for the year 2008–09.

Table 7: Financial summary of the Indian telecom industry

Sr. no.	Indicator	2004-05	2005-06	2006-07	2007-08	2008-09
1.	Total Revenue (Rs. billion)	716.74	867.20	1053.18	1290.83	1523.60
	Contribution of government companies	421.74 (59%)	452.33 (52%)	454.72 (43%)	432.49 (34%)	411.62 (27%)
	Contribution of private. companies	295.00 (41%)	414. 87 (48%)	598.45 (57%)	858.34 (66%)	1111.98 (73%)
2.	Total EBITDA (Rs. billion)	267.86	301.38	391.67	n.a.	n.a.
	Government companies' EBITDA	186.13	187.09	195.86	n.a.	n.a.
	Private companies' EBITDA	81.72	114.29	195.80	n.a.	n.a.
3.	Capital Investment (Gross Block[9]) (Rs. billion)	1788.31	2006.66	2346.87	n.a.	n.a.
	Gross Block – government companies	66%	64%	57%	n.a.	n.a.
	Cross Block - private companies	34%	36%	43%	n.a.	n.a.
4.	Capital employed[10]	1538.64	1700.87	1898.34	n.a.	n.a.
	Capital Employed – government companies	n.a.	1042.31	1030.71	n.a.	n.a.
	Capital Employed - private sector	599.25	658.56	867.63	n.a.	n.a.
	Return on Capital Employed (RoCE)	n.a.	7.82%	10.64%	n.a.	n.a.
5.	Cumulative FDI in Telecom (Rs. billion)	67.14	94.90	116.45	167.47	284.74
	(Percentage of total FDI)[11]	3.32%	11.28%	3.05%	5.17%	9.54%
6.	Gross Domestic Product (Rs. billion at factor cost) Current Prices	28771.07	32823.85	37793.85	43208.92	49331.83
	Share of Telecom sector to GDP	2.49%	2.64%	2.79%	2.99%	6.03%
7.	Cumulative Telecom FDI (5) as percentage of Capital Investment (Gross Block) (3).	3.75%	4.73%	4.96%	n.a.	n.a.
8.	Total Employees of Telecom Companies	436891	429400	432771	n.a.	n.a.
	Government companies	394334	382105	369035	n.a.	n.a.
	Private companies	42557	47295	n.a.	n.a.	n.a.
	Subscribers per Employee at year end					
	Government companies	132	158	193	n.a.	n.a.
	Private companies	1089	1678	2110	n.a.	n.a.

Source: Telecom Regulatory Authority of India (TRAI) performance indicators reports from 2004-05 to 2008-09.

Note: n.a. = Not Available.

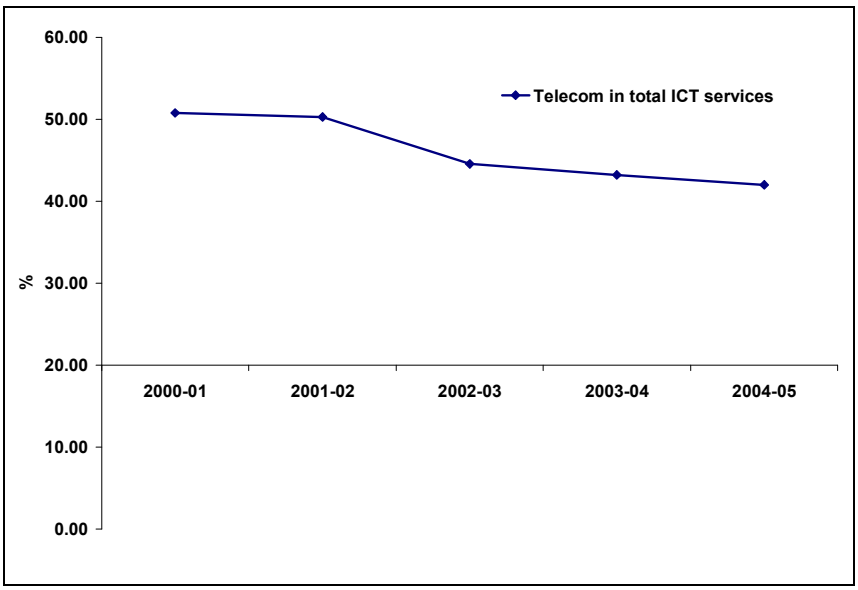
Figures 2 and 3 are derived from Table 5. As can be seen from the table, telecom accounted for almost 51% of the total ICT services value added in 2000-01, which reduced to 42% in 2004-05.

[9] Gross Block is the Gross Capital Investment or the stock of investment.

[10] Capital Employed is the fund deployed to operate the business.

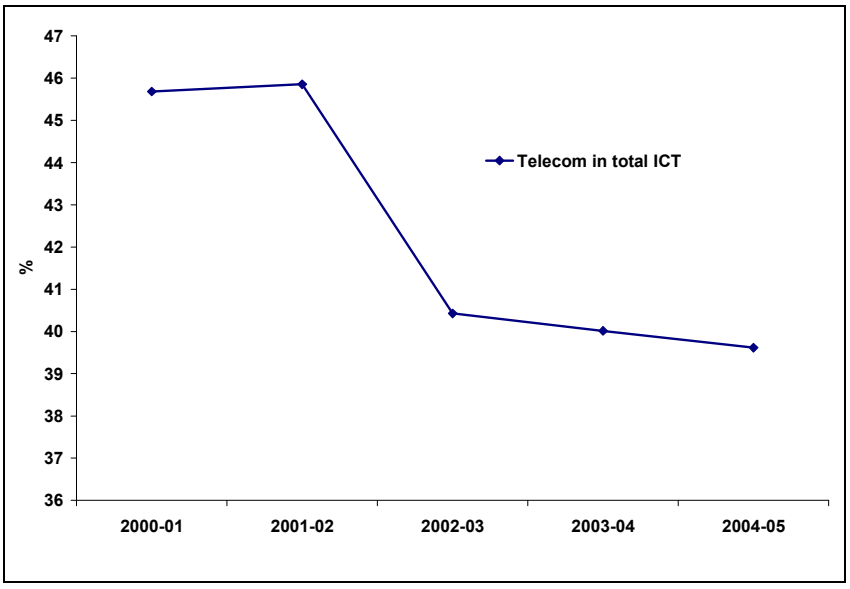
[11] Telecom FDI inflow as a percent of total FDI inflow.

Figure 2: Percentage share of telecom in total ICT service value added



The share of telecom in total ICT value added was also almost constant (around 46%) during 2000-01 and 2001-02, which then experienced a sharp reduction to reach 39.62% in 2004-05.

Figure 3: Percentage share of telecom in total ICT value added



In her study, Malik (2007) shows that competition-induced decline in tariffs (and, hence, increased affordability) resulted in the wireless telephony boom in India. Tariffs reduced up to 35% during 2003-04. IPLC charges decreased by 35% for low capacity and 70% for higher capacities. The Indian case study clearly demonstrates that competition can deliver, and hence should be fostered by regulation and policy (Malik, 2010).

Table 8: Important policy and regulatory milestones in the Indian telecom sector

New Telecom Policy – 1999	The service-providing arm of the Department of Telecom separated from the policy-making and licensing functions.
	Creation of corporatised BSNL in October 2000.
	BSNL/MTNL allowed to enter as the third cellular service provider in all circles.
	National long-distance market thrown open for competition.
	Wireless Planning and Co-ordination Committee created to review and enforce spectrum allocation policy.
Lowering the Licence fee – 1999	Government changed the prevailing fixed annual licence fee to a revenue-share regime.
Interconnect Usages Charges regime – 2003	IUC regime of 2003 clearly specified the interconnect charges.
	Paved the way for a calling party pays (CPP) regime – subscriber no longer had to pay for incoming calls, making the mobile phone highly affordable to low-usage customers who mainly used it for incoming calls.
	Termination charges made uniform for all types of calls – cellular mobile, fixed and WLL (M).
Unified Licence	Allowed an operator to provide fixed and/or mobile service using any technology.
	The objective was to allow the exploitation of technological developments to the fullest extent to provide new applications and services.
	The first phase of implementation, the Unified Access service licence, was readily adopted by most of the major operators
Lowering of Access Deficit Charge	Feb 2005: The per-minute ADC on domestic long-distance calls reduced by up to 60%, and the ADC on international calls by up to 40%.
	March 2006: The per-minute ADC for domestic calls replaced with a revenue-share fee of 1.5% of non-rural (wireline) AGR, coupled with a sharp 60% drop in per-minute ADC on international calls.
	March 2007: ADC on revenue-share percentage reduced to 0.75% from 1.5% of AGR. Per-minute ADC on outgoing international calls reduced to zero, and on incoming international calls reduced to Rs. 1.
Lowering duty of telecom equipment - 2003-05	Union Budget 2003-04 cut the customs duties on telecom sector capital goods from 25% to 15% and on cell phones from 10% to 5%.
	Union Budget 2004-05 exempted imports of capital goods for manufacture of mobile handsets from customs.
Roaming Charges	Jan 2007: Roaming rental reduce to zero. Reduction of roaming tariffs to the extent of 22%-56%.
Port Charges	February 2007: Port charges reduced by 23-29%.

Source: TRAI consultation paper on cap on access providers, April 2007.

1.3.2. Computer Services and Software (CSS)

IT services, software and BPO constituted 81% of USD 64 billion of the total ICT sector revenue in 2007-08 (Table 4). Software and IT services have contributed more revenue (USD 40 billion in 2007-2008) than ITES/BPO (USD 12.5 billion in 2008). In software and services most of the revenue comes from on-site services, where Indian firms send workers to client sites abroad on an hourly basis, which is known as body shopping. 'Offshore' services form a small proportion of the total revenues. In these projects, Indian firms are given the project specifications and responsibilities to execute the projects in the Indian offices; Indian

programmers go to the client's office only during integration. Here, Indian firms have better control over projects in terms of division of labour, deadlines and execution.

The higher revenue contribution from onsite services suggests that is it composed of low-end activities like maintenance and testing of existing client software rather than high-end software services driven by intellectual property blocks and patents. In terms of geographical concentration, most of the revenues are generated from the US. Among the industry domains, banking, financial services and insurance (BFSI) constitute more than the others (Table 9).

Table 9: Indian ICT industry structure 2007-08

Description	Details
Revenue (USD billion)	Software and Services– 52 Hardware – 12
Revenue (USD billion)	Business Process Outsourcing / IT-enabled services – 12.5 Software services – 40
Major export destinations in percent of composition	US – 60%; Europe – 32%
Composition of industry verticals in exports.	Banking, Financial Services and Insurance – 41%; Hi-tech / telecom – 20% Manufacturing – 17%.
Share of top six Indian ICT geographical regions	97%

Source: The Indian IT-BPO sector, Strategic Review, NASSCOM, 2009.

In the late 1990s, Indian software firms diversified into providing back-end services, also called ITES (or the call centre industry), that are equally successful. However, the ITES sector is smaller than the software services sector. This unevenness of the services exports makes the industry vulnerable to global market fluctuations. For instance, changes in temporary visa legislations in the US would have a negative impact on the revenue flow of the onsite-dominated industry. Due to the current slowdown, BFSI segments have been affected, resulting in a decline in revenues for the entire industry.

The success of the Indian software sector is largely attributed to the availability of high-skilled technical labour for exports. Indian software services firms exploited the under-utilised engineering talent produced after independence to meet rising global needs, especially from the US, which is the world's largest consumer of software. India's rise in the global ICT sector during the Y2K boom period is well documented (Balakrishnan, 2006; Parthasarathy, 2004). Two major developments served as catalysts: the exit of IBM in the 1970s left numerous machines in India that provided services opportunities to Indian entrepreneurs and the establishment of Texas Instruments in Bangalore enabled companies to execute designs whose subsequent success demonstrated the feasibility of providing software services using local capabilities.

According to Balakrishnan (2006), three types of Indian firms drove the Indian services sector:

- entrepreneurial firms started by professionals who were working for multinationals in the early 1980s (for example, Patni Computer Systems and Infosys),
- ICT manufacturing firms that diversified into software (for example, HCL and Wipro),
- software divisions started by established industrial groups (for example, TCS and Satyam).

Recent research studies give credit to the recent impetus provided by government policies (Balakrishnan, 2006; Sharma, 2009). Software technology parks (STP) were introduced in 1991. Under the STP scheme, firms are allowed to import equipment without an import license or having to pay import duty. Similarly, equipment purchased from the domestic market is exempt from excise duty. Foreign equity up to 100% is permitted and firms are allowed to freely repatriate capital investment, royalties and dividends after paying the necessary taxes. In return, there is an export obligation. Firms have to earn a net amount equal to 150% of the hardware imported within four years. They also have to earn a net amount equal to 150% of their wage bill on an annual basis. Although the STP scheme was meant for 100% export units, in January 1995 STP firms were allowed to sell up to 25% of the value of their exports to the domestic tariff area. The figure was revised to 50% in 1999 (Parthasarathy, 2004, p.18). Also, firms registered under the STP scheme get income tax exemption on export earnings for 10 years.

1.4. Regional distribution of ICT activities

There is no direct data available on the regional revenue distribution of the industry. However, the presence of ICT firms in six clusters, namely, Bangalore (Karnataka), Mumbai and Pune (Maharashtra), Chennai (Tamil Nadu), Hyderabad (Andhra Pradesh), and the National Capital Region [New Delhi (Delhi), Noida (Uttar Pradesh) and Gurgaon (Haryana)], is prominent and almost 97% of the export revenue came from these regions (NASSCOM, 2009). Similar generalisations can be made for overall industry revenues. Other cities like Mysore, Visakhapatnam, Coimbatore, and Ahmedabad are also slowly developing into ICT clusters. Khomiakova (2007) generated a regional comparison of revenues in software exports based on interviews with Indian software technology parks. But the data is presented for the states rather than the cities. Nevertheless, the revenue composition reflects the dominance of the six established IT cities or regions (Table 10).

Table 10: Software exports from Indian states

State	2002-2003	2003-2004	2004-2005	2005-2006	Growth (%) 2004-2005 to 2005-2006
Karnataka	12350	18100	27600	37000	34
Maharashtra	5508	8518	11542	15500	34
Tamil Nadu	6305	7621	10790	13960	29
Andhra Pradesh	3668	5025	8270	12500	51
Haryana	2734	4292	5953	8358	40
Uttar Pradesh	2541	2750	3825	5476	43
Delhi	2065	2398	2453	3520	43
West Bengal	1200	1600	2000	2500	25
Orissa	260	319	400	465	16
Kerala	165	212	270	296	10
Chandigarh	31	39	225	294	31
Rajasthan	47	130	200	271	36
Gujarat	105	141	187	247	32
Madhya Pradesh	107	102	140	189	35
Punjab	70	182	125	182	46
Pondicherry	15	22	30	40	33
Others	5	8	9	11	25
Total	37176	51459	74019	100809	36

Source: Reproduced from Khomiakova, (2007), p.12. Data are based on author's interviews at Software Technology parks of India.
Note: Figures are in Rs. 10 million.

A comparison of the major ICT clusters shows that the Bangalore cluster is the most mature ecosystem for the ICT industry (Balachandirane, 2007; Biswas, 2004; Khomiakova, 2007). Due to its historical lead advantages, it has a deep labour market, proximity of well-known research institutes, government research labs, the presence of venture capital, and a healthy mix of large domestic firms, multinationals and other supplementary firms. Bangalore is widely called India's Silicon Valley.

Table 11: Profiles of the top six ICT clusters

Dimension	Bangalore	Delhi, Gurgaon, Noida	Chennai	Hyderabad	Pune	Mumbai
Cluster Density	Dense	Dense	Dense	Dense	Dense	Dense
Cluster Breadth	Broad (potential for ICT, Bio-IT)	Broad	Broad (potential for ICT)	Broad (potential for ICT)	Broad (potential for ICT, Bio-IT)	Broad
Activity Base	Activity-rich along the value chain in IT services, software, ITES-BPO, R&D, hardware	Activity-rich along the value chain: BPO, IT services, software, R&D, hardware	Activity-rich, strong application and system software, strong hardware, ITES-BPO	Activity-rich along the value chain in IT services, software, ITES; strong in chips	Very active in product development, R&D-intellectual property hub; IT serves presence	Activity-rich along the value chain in IT serves, software, ITES hardware
Anchor company Computer hardware	Solectron, personal Internet device for AMD; MRO-Tek 2, manuf, plants for network/telecom; Flextronics, set-top boxes for Galaxis	Noida: Sahara Computer, PC and peripherals Samsung, monitors	Wipro, PC and laptops; IMP/Lenovo, PC and laptops; TVSE, printers and peripherals	Semi-com and AMD project for semi-conductor mfg.	Not available	Kobian, motherboards and graphics boards; PCS PC and laptops
Anchor company IT services, software and R&D, ITES-BPO	Infosys (HQ), Wipro (HQ), Digital Global Soft (HQ)	HCL (HQ), Hughes (HQ), Genpact, Samsung.	Polaris (HQ), NIIT/ training (HQ)	Satyam Computer Services Ltd. (HQ)	Compulink Systems Pvt Ltd. (HQ)a, also centres of Infosys, TCS, WNS, and Honeywell	TCS (HQ), Patni (HQ) Tata Infotech Ltd. SGlobal Tele-System
Innovation Capacity	High	High	High	High	High	High
Ownership Structure	Combination of foreign-owned and locally owned firms	Significant share of local small and medium-sized enterprises, presence of multinational and Indian top companies	Combination of foreign-owned and locally owned firms	Combination of foreign-owned and locally owned firms	Significant share of local small and medium-sized enterprises, small presence of multinational and Indian top companies	Combination of foreign-owned and locally owned firms

Pune is smaller than Bangalore, but it emulates Bangalore. It also has a good mix of research institutes, high-technology entrepreneurial cultures and a deep labour pool. The National Capital Region (NCR) is emerging as a BPO centre due to the large number of graduates and its culture, which is less conservative than in South India; it is similar to Hyderabad and Chennai in the software domain. Hyderabad and Chennai are late entrants, but due to aggressive policy initiatives, they are supplementing the software requirements of other clusters. In industry terms, Bangalore is a 'development centre', while Hyderabad and Chennai are 'production centres'. Though Mumbai was a front runner where many ICT firms have registered headquarters, it does not have a clear identity and growth is stagnant due to the shortage of land for commercial purposes; Mumbai's limitations have been exploited by Pune. Though the government is making efforts to spread the ICT industry to Tier II and Tier III cities, desirable growth is yet to be seen (Hutchinson and Ilavarasan, 2008). Khomiakova

(2007) compares the clusters on selected dimensions using secondary data. A collaborative study by Evaluserve and the Government of India highlights five clusters as places of innovation (Table 12).

Table 12: Innovation Clusters in India

R&D/INNOVATION CLUSTERS	MAJOR MNCs	EDUCATIONAL/RESEARCH INSTITUTE	OTHER LOCATION BENEFITS
Bangalore	Texas Instruments, Oracle, Sun, Microsystems, IBM, SAP Labs India, Philips Innovation Campus, HP Labs, Cisco, Intel, GE, GM, Motorola, etc.	Indian Institute of Science, Indian Space Research Organisation, National Aerospace Laboratories, CSIR Centre for Mathematical Modelling and Computer Simulation, National Centre for Biological Sciences, Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore Institute of Technology, B.M.S. College of Engineering, Ramaiah Institute of Technology, C-MMACS, etc.	▪ Government institutes nurturing industry academia partnerships ▪ Larger number of existing R&D companies resulting in better networking.
National Capital Region (NCR)	Adobe, AVL, Ericsson, ST Microelectronics, Honda, IBM, etc.	IIT Delhi, Delhi College of Engineering, All India Institute of Medical Sciences, Indian Agricultural Research Institute, National Physics Laboratory, National Institute of Science, Technology and Development Studies, Delhi University, etc.	▪ Proximity to the central government ▪ Availability of finance and venture capital ▪ Better infrastructure with facilities such as Delhi Metro and good road conditions.
Pune	Microsoft, Oracle, Siemens, Tata Motors, Whirlpool, etc.	National Chemical Laboratory, National Centre for Cell Science, Agharkar Research Institute, International Institute of Information Technology, College of Engineering, Vishwaakama Institute of technology, Maharashtra Institute of Technology, etc.	▪ Proximity to India's commercial capital, Mumbai. ▪ State government support by providing entry tax exemption on all goods purchased by IT companies and launch of an incubator programme supporting start-ups.
Hyderabad	Microsoft, Nokia, Motor Graphics, Motorola, DuPont, AMD, etc.	Centre for Cellular and Molecular Biology, National Academy of Agricultural Research Management, National Institute of Chemical Technology, Birla Institute of Technology and Science, etc.	▪ Large number of existing IT and biotech companies. ▪ Biotech hub of India, also known as the Genome Valley.
Mumbai	Bayer AG, Clariant, Reliance, Johnson & Johnson, Pfizer, etc.	IIT Bombay, Indira Gandhi Institute of Development Research, National Centre for Software Technology, Central Institute for Fisheries Education, Tata Institute of Fundamental Research, VJTI, University, Institute of Chemical Technology, etc.	▪ Availability of venture capital ▪ Better connectivity through various means of transport such as railways, roads, water and air transport.

Source: Evaluserve, 2007.

Indian ICT firms are exploring second-tier cities as alternatives, as the existing clusters are not able to sustain the exploding growth with limited infrastructure and rising labour and land costs.[12] For instance, Bangalore, the top-rated ICT city, suffers from traffic congestion, power

[12] The discussion on second-tier cities is based on an earlier work undertaken by the researcher. For details, refer to Hutchinson and Ilavarasan (2008).

shortages and inadequate airport facilities, rising real estate prices, and high levels of poaching and staff turnover. State governments are responding to this opportunity by courting foreign investment from large multinationals, and are negotiating loans and financing directly with international financial institutions such as the World Bank. Thus, states that have yet to enjoy the benefits of these new industries are eager to attract investors, often offering additional incentives and individual attention (Silicon India, 2008). In addition, states such as Karnataka, Maharashtra, and Andhra Pradesh that have established industries are keen to decongest their cities and spread the benefits of growth to secondary centres (Business Line, 2007).

Central policies have been facilitating the growth of this sector. At the central level, the agency that offers export-oriented firms dedicated infrastructure and facilities, Software Technology Parks of India, has begun to set up parks in many second-tier cities. Recent industrial policy measures, especially related to special economic zones (SEZs), will also allow smaller IT parks more appropriate to smaller cities to be set up.

The move to spread the industry to new locations is being adopted by larger firms. A research study among 123 IT/ITES firms (NASSCOM Foundation, 2008) indicates the growing importance of second-tier cities, with 73% of participants having a presence in second-tier cities.

This movement is not limited to local operations, as multinationals are also setting up facilities outside Tier I locations. Honeywell set up operations in Madurai (Tamil Nadu). GE has facilities in Jaipur (Rajasthan), and IBM and Dell have set up operations in Coimbatore (Tamil Nadu).

First-tier locations that are established ICT clusters or cities will continue to be the prime locations for IT/ITES operations in the years to come. This is due to factors such as their well-developed labour markets, established lobby groups, and developed support industries. In particular, due to their established reputations, first-tier cities will continue to be popular with first-time investors to India that want to minimise risk.

That said, increasing problems due to infrastructure constraints and related problems will drive established firms outside Tier I locations. In particular, international firms that have a deep knowledge of India, a large appetite for risk, and larger workforces will be more likely to seek less congested roads, lower rates of poaching, and cheaper real estate. Similarly, large local firms, particularly those that can afford to maintain a representative office in an industry hub, as well as smaller niche players that have established domain expertise, will be likely to seek more conducive environments for business.

In addition, second-tier cities offer considerable advantages as alternative locations for non-critical operations. The business association, ASSOCHAM, calculated that second-tier cities offer an average cost advantage of 15% over first-tier cities. Relatively untapped real estate markets mean lower direct costs and shorter waits for permits. Many of these cities have good local colleges, meaning that graduates are cheaper, easier to find, and, due to the proximity of their families, easier to retain.

However, this process does have significant drawbacks, as moving outside established centres implies some risk and inconvenience. The experiences of firms located in second-tier cities offer some insights (NASSCOM, 2006a; 2006b). Of concern are: the existence of a local

airport; the frequency and timing of flights to major centres; hotel capacity; the reliability of the power supply; and the existence of support services. Further, while land is readily available, the availability of construction companies with the desired experience and expertise is far from certain. Time and cost over-runs in building the highly-specific facilities for IT/ITES operations can be frequent.

There are also issues regarding human resources. The quality of the graduates in second-tier cities is not encouraging, particularly with regard to spoken English. For instance, in Jaipur, the leading second-tier city, "employability was just 6% of the total available pool of 27,000 people per year" (NASSCOM, 2006b). Also training facilities which IT/ITES firms share may not exist; the presence of one or two firms may be enough to dry up available labour. In addition, experienced managers may be reluctant to move to smaller cities with less vibrant career prospects. Cultural factors can also affect operations, as traditional attitudes to women may prevent them from working in the late evenings or nights.

Smaller cities may also be far-removed from government officials and lack the critical mass of firms necessary to pressure state and local governments for necessary legislation and service quality. Thus, firms without branches in capital cities will find themselves isolated from policy-makers.

Therefore, with regard to second-tier cities, it appears that the IT/ITES industry is in the midst of the 'open window of locational opportunity'. At present, firms are making investments based on labour arbitrage and the existence of cheaper inputs. However, over time, the number of IT/ITES clusters in these cities will shrink because firm clusters have not had time to generate traded and untraded interdependencies such as specialised supplies of labour, more efficient inter-firm collaboration with the resulting productivity gains, or collective reputation effects. This will change over time, as firms in these different locations start interacting with each other and their surrounding institutions. As this happens, some firm clusters will begin to outperform others as their regional economic commons develops and improves productivity. A key part of this story will be how state and local government officials react to and foresee firm needs. It is also likely that the distribution of IT/ITES firms across second-tier cities will be quite specialised, as different locations offer investors distinct advantages according to their specific attributes.

Large local and international investors that want large numbers of skilled workers and good infrastructure and are willing to pay mid-range prices will most likely cluster in state capitals with large industrial sectors. Potential candidates include Kolkata, Ahmedabad, Chandigarh, and Lucknow as they have relatively well-developed infrastructure, good universities, and easier access to state government machinery. Over time, the cities with deeper stocks of skilled labour, more responsive state institutions, and better organised industry associations will begin to pull ahead. Given their late entry into the sector, it is unlikely that these cities will become Italian-style industrial districts. However, a number of these second-tier cities could become durable hub-and-spoke clusters, with a large firm and its suppliers steering the cluster, as larger firms establish their operations and generate a demand for supporting services. The challenge for policy-makers will be to go beyond providing infrastructure to strengthening local business associations, seeking to attract and retain promising lead firms, and encouraging the broadening of the base of supplier firms.

Smaller local and international investors, particularly niche operators, seeking lower labour and real estate costs – as well as 'life-style' factors such as lower commuting time and a more

family-friendly environment – will target smaller cities close to prime industry centres. Mysore near Bangalore, Trichy near Chennai, and Pune, a few hours away from Mumbai, belong to this group. In addition to their own attributes, these cities are able to piggy-back on their neighbours' 'hard' and 'soft' infrastructure such as airports, training facilities, and industry associations. However, while labour may be more readily available, retention may be a problem as graduates move to the bigger city after gaining experience. And, given their symbiotic relationship with their first-tier city, the future of these clusters is inextricably linked to them. That said, these cities could conceivably come to host a number of smaller, niche firms from their 'mother' cities. Here the challenge for policy-makers will be to preserve or improve the lifestyle factors that attract firms, as well as improving links to the first-tier city they support. Attempts to foster greater inter-firm interaction and collective learning should also be undertaken, as competition will emerge from other nearby urban centres.

Local firms with an appetite for risk may chose to locate in cities that do not have an industrial tradition, but offer a sufficient quantity of workers and adequate infrastructure. Examples include Jaipur in Rajasthan, Coimbatore in Tamil Nadu, and Visakhapatnam in Andhra Pradesh. These cities offer large cost reductions in terms of land and labour. However, due to their relative isolation and low exposure to industry needs, they may have high transaction costs, an unresponsive bureaucracy, and shallow pools of skilled labour. In addition, the non-existence of business associations may make collective action particularly difficult. These cities will be reduced to relying on one or two lead firms, more often than not headquartered elsewhere. Given the hosting region's limited resources, it is unlikely that lead firms will choose to locate high-value services here. Thus, this activity will provide a number of white-collar jobs for local residents, but little beyond that. At an early state, specialised infrastructure and tax incentives will be crucial to attract investment. However, the long-term challenge is to go to beyond this, and persuade lead firms to locate more sophisticated tasks in the given region as well as to interact with local firms.

1.5. Evolution of the Indian ICT sector in the past 20 years

The evolution of the Indian ICT sector can be mapped into approximately three phases: until 1984, from 1984 to1990 and post-1990 (Parthasarathy, 2004). In the first phase, apart from trying to establish its own technological trajectories, the state attempted to run the industry which resulted in no commercial sector. In this phase, there was no great differentiation between software and hardware. In the second phase, the government realised that software was a viable option for income generation and technological capability enhancement. Restrictions were loosened but there was no vision for the industry and lack of knowledge about the industry plagued the policy-making process. However, the end of the second phase saw the emergence of industry-friendly policy initiatives that were skewed towards software exports. In the third phase, the software export industry blossomed, aggressively promoted by both national and state governments. Consequently, the export-driven growth model ignored the hardware sector and the domestic sector, despite their huge potential (Parthasarathi and Joseph, 2002). Though the scenario is rapidly changing from providing low-end onsite services to high-end offshore services, with increased investments in semiconductor manufacturing, the Indian ICT sector is predominantly seen as a software services exporter.

Major milestones in the evolution of the ICT sector in the past twenty years are presented in Table 13.

Table 13: Evolution of Indian ICT sector

Year	Event / Description
1978	• IBM disagrees with the Indian government on diluting foreign equity to 40%, under FERA (Foreign Exchange Regulations Act), and exits from India, leaving its domestic installations. • Indian firms undertake maintenance of IBM installations in the country.
1981–1982	• The present top 20 firms – Infosys and NIIT – are started. Infosys provided software services, while NIIT ventured into the training segment. • Establishment of national super-computing facility at the Indian Institute of Science, Bangalore.
1984	• Introduction of new computer policy – reduction of import duties for peripherals, permission for foreign equity participation, recognition of software as a separate industry. • Centre of Development of Telematics (C-DOT) was established to design and manufacture indigenous telecom systems required by the country.
1985	• Selected banks and railway reservation counters were computerised, marking the beginning of the use of computers in the non-academic and research domains. • First computer supermarket selling computers and peripherals to non-industry customers was started in Mumbai. • Texas Instruments (TI) starts its Bangalore office despite bureaucratic hurdles in the forms of clearances from multiple state agencies. TI is the first multinational firm to successfully demonstrate that outsourcing can be done in India.
1986	• Introduction of first software policy which showed an understanding of the industry and sent positive signals to potential investors. Policy efforts include de-licensing of the industry, emphasis on training, permission to import hardware and software, and a strong software export commitment from firms, thus encouraging exports.
1987	• Entry of MNCs through a host of tie-ups with local firms. MNCs used domestic firms as a buffer to deal with policy risks, explore the domestic market and exploit local capabilities for global competitiveness.
1988	• Establishment of NASSCOM (National Association of Software and Service Companies) • Formation of Electronics and Software Promotion Council (ESC). • Software gets complete exemption from excise duty.
1990	• Entry of first super computer CRAY XMP-14.
1991	• Introduction of Software Technology Parks of India (STPI) scheme which is the most important catalyst for the birth of the software export sector in India. This scheme includes single-window clearance to set up firms, no import duty, 100% foreign equity, and income tax exemption on export earnings for 10 years. • Saha Computers & Communications, the first Indian firm to manufacture laptops, thus showing improvements in technological capabilities or collaborations. • Joint venture between HCL and HP to develop multiprocessor UNIX for HP, indicating signs of contract R&D in the early phases.
1992	• IBM returned to India to sell hardware, software and export software services. • iFlex, a banking software product firm, currently the leading product firm from India, was started.

Year	Event / Description
1993	• Indian programmers need to get H1-B visa to work in the US. The huge demand in the US for low-skilled programming services during the Y2K phase led to most firms carrying out body-shopping. Indian firms started sending programmers on short term contracts to the US to work onsite. Later these services were converted into software maintenance work in the US firms, making onsite one of the major revenue earners of the Indian industry.
1994	• National Telecom Policy is announced which in turn decreases the cost of telecom infrastructure and increases communication facilities. • Indian firms started exploring foreign locations as branches as they gain confidence through onsite work. Wipro sets up R&D centre in the US; Infosys opens a US subsidiary. • HCL-HP delivers India's first Pentium machine.
1995	• First cyber café opened in Mumbai. • National-level online railway reservation introduced, showcasing ICT capabilities. • VSNL, a public firm, introduces India's first full Internet for public access.
1996	• Rediff.com, India's premier dotcom, is launched as its Internet penetration increases generally and not only in areas that serve India-specific information needs abroad.
1998	• The National IT Task Force formed by the Government of India which envisioned the growth of the IT industry apart from making the government digital. • MNCs start exploring the feasibility of using local expertise for developing global technologies. Many MNCS set up research labs in academic institutes. • Centre for Development of Advanced Computing (C-DAC) develops first indigenous supercomputer, PARAM 1000.
1999	• Infosys is the first Indian firm to be listed on NASDAQ. • 100% FDI in IT industry recommended. • National Telecom Policy, 1999
2000	• HP Global set up in Bangalore for back-office work. • Bangalore and clusters like Chennai, Hyderabad and Delhi emerge as IT clusters.
2001	• Growth rate of the industry dips due to tech-led slow down, 9/11, and 12/13.
2002	• Centrino mobile technology launched in India.
2004	• Pro-IT government loses power in two provinces, Karnataka and Andhra Pradesh, making political parties cautious about pro-IT policies. • Indian software firms cross billion dollar barrier. • Broadband policy announced, permitting use of 2.4 GHz in outdoor locations.

Source: Authors' compilation from Dataquest, 2006.

2. ICT SECTOR: COMPANY-LEVEL ASSESSMENT

2.1. ICT firms and their R&D centres

Firm-level data are not available in either government sources or the NASSCOM datasets. A trade press magazine, *Dataquest*, collects information on selected parameters including revenues and the number of people employed on an annual basis. According to Dataquest (2008), the top 200 firms contribute 86% of the total revenues of the Indian ICT industry, of which the top 20 firms contribute about 63% of the total revenue, the next 30 firms contribute about 17% and next 150 contribute about 20%. Multinational firms also dominate industry revenues with 12 firms listed among the top 20 firms and around 67% in the top 200 firms. This information on the industry's composition has to be treated with caution as the information received by the magazine is voluntarily given by the firms. Nevertheless, Dataquest helps us get details of ICT firms in India which are not available to researchers.

The composition of the firms in the industry is given by NASSCOM (2009), which divides the firms into four categories based on the number of employees and revenue – large-sized players, mid-sized players, emerging players and small/start-ups (Table 14). The major drawback in the NASSCOM data is the lack of detail on the firms and ICT sub-sectors. Also, data on the industry's composition is drawn from 'annual reports, press articles and company presentations' (p.53).

Table 14: Structure of Indian IT-BPO industry

Type of firms	No of firms	Employees	Major players
Large-sized players	Seven, each with revenues more than USD 1 billion	40,000 and above	Indian, multinational firms
Mid-sized players	75– 80, each with revenues in the range of USD 100 million – 1 billion	5000 – 40,000	Multinational firms
Emerging players	300– 350, each with revenues of USD 10– 100 million	100 – 5000	Indian firms that are captive centres of multinationals
Small / Start-ups	More than 3500, each with revenue less than USD 10 million	Less than 73	Indian firms

Source: Adapted from The IT-BPO sector in India, Strategic Review, NASSCOM (2009).

A survey of 2,152 R&D units by the National Science and Technical Manpower Systems unit (NSTMIS) of the Department of Science and Technology, Government of India show that, "as on 1 April 2005, 391,149 people were employed in research and development establishments. Of these, 39.6 % were primarily engaged in R&D activities. 27.0 % were performing auxiliary (technical supporting) activities and 33.4 % were providing administrative or non-technical support. The personnel engaged primarily in R&D activities and auxiliary activities are invariably S&T qualified" (National Science and Technical Manpower Systems, 2009; p.15).

The NSTMIS study also reports that "out of 154,827 R&D personnel (personnel primarily engaged in R&D activities), 75,367 (49.0%) were employed in the institutional sector, 22,100 (14.0%) in higher education sector and the remaining 57,360 (37.0%) were employed in the

industrial sector as of April 1, 2005. With regard to 105,808 auxiliary personnel, the distribution among the institutional and industrial sectors was 83.0% and 17.0% respectively" (National Science and Technical Manpower Systems, 2009; p.16).

As there were only 21 units from the IT domain of the 2,152 units surveyed in this study, we should not expect a significant number of R&D personnel to be working in the ICT sector. A private consulting firm (Zinnov, 2008) reports that 146,760 R&D professionals are working in the ICT industry's R&D centres. This number has to be treated with a caveat as it treats all employees in R&D centres as full-time employees. Also, the Zinnov study does not provide details on the methodology, especially on the definition of R&D centres and R&D personnel.

There are two sets of players who perform R&D activities: large domestic players and subsidiaries of multinationals. Large domestic players undertake two kinds of innovative activities: internal and external. Internal activities help in service delivery process improvement and are consumed by the firms themselves. The amount spent on these activities is not shown by the firms. The compilation by independent academic researchers shows that R&D expenditure by Indian firms is very low. For instance Nollen (2004) studied 278 firms listed on the Indian National Stock Exchange to understand the R&D in the Indian ICT sector.

> *"*Only 12 or 4.3% of all listed software firms in India had lab or R&D equipment expense. The median expense for firms with this expense was 0.4% of sales revenue and the average was 3.8%. Less than 1% of the revenue generated by the Indian software industry is spent on R&D. 63% of Indian and foreign IT firms (computer hardware & software, telecom equipment & services, industrial electronics) operating in India reported R&D expense in 1999/2000 but only 9.6% of these firms reported innovative rather than adaptive R&D."
>
> (Nollen, 2004; p.11)

The second set of activities is performed for external clients who outsource their product development activities. In industry terms these are called 'engineering services and R&D and software products' and is listed as high-end work. It contributed USD 8.6 billion in 2008 and constituted around 13% of total industry revenues in 2008. 74% engineering services and R&D and software products is exported. However, the revenue generated from software products or licensing of software intellectual property blocks by firms in India is small, with only USD 1.1 billion of the total revenues of the industry and USD 64 billion in 2008 (NASSCOM, 2009).

Zinnov (2008) reports that there are around 594 R&D centres in the ICT industry in India. It appears that all MNCs are termed R&D centres and all the employees are treated as R&D personnel by the Zinnov study. An attempt made by Ilavarasan (2010) to collate the list of R&D centres resulted in only 160 centres for which at least some information is available. However, Zinnov (2008) does suggest some trends. Though the entry of R&D centres into India started in the mid-1980s, it gained momentum in the mid-2000s after Indian firms successfully demonstrated that they could deliver large software projects. Supposedly, between 2003 and 2005, 262 centres were started (Zinnov, 2008). It is possible that India as a successful outsourcing destination was established in the post-Y2K period and multinationals were looking for foreign geographies to outsource their software development. Of the existing R&D centres, 66% are in the software product development domain, 15% in engineering services and 20% in the embedded systems area. The break-up of the verticals of these R&D

centres show that enterprise software dominates with 26% followed by telecom and networking at 19%. Consumer software is the lowest with 3% (Table 15).

Table 15: Structure of industry verticals of ICT R&D centres

S. No.	Verticals	Percentage (N=594)
1	Consumer software	3
2	Enterprise software	26
3	Software platforms / systems	14
4	Semiconductor / Electronic Design and Analysis	13
5	Telecom & Networking	19
6	Consumer electronics	8
7	Computing systems	9
8	Manufacturing	9

Source: Adapted from Zinnov (2008).

A comparison of R&D centres by employee size and global revenue shows that about 48% of them have revenues of less than USD 100 million. The distribution of centres in terms of headcount is homogeneous, with a slight domination of firms with a headcount of 10–50 with 29% (Table 16). Among the various regions, Bangalore is the preferred destination with 52% of the firms, followed by Pune at 16% and the NCR at 15%.

Table 16: Distribution of R&D centres by headcount and global revenues

Headcount (Employees)	Revenue (USD million)			
	1–100 [48]	100–200 [9]	200–500 [13]	500+ [31]
10–50 [29]	23	3	1	3
50–100 [23]	14	2	2	5
100–200 [21]	7	2	5	8
200+ [27]	4	2	5	15

Source: Adapted from Zinnov (2008). Figures in brackets show the percentage of firms in each category.

Another indicator of R&D levels in the Indian ICT sector is patent data. There is no data available to researchers in the Indian patent office. However, analysis by independent researchers and trade press reports show that more patents were awarded to multinational firms than to Indian firms. For instance, Nollen (2004) showed that in the year 2001–2003, only four US software patents awarded to Indian firms compared 118 patents awarded to US and other foreign firms operating in India. Evidence by Dataquest (2008) reinforces this view (Table 17).

Table 17: Patents by ICT firms in India

Firm	Patents Granted in 2008	Patents Granted in 2007
HP (multinational)	50	77
Infosys	2	0
TCS	17	3
Sasken	5	6
Subex	8	4
i-flex	0	0
Mindtree	0	0

Source: Adapted from Dataquest (2008).

Note: This table is indicative, as the list is not exhaustive. Texas Instruments India centre, one the top patent filers, is missing from this list.

On traditional measures like patents or copyrights, most of the innovation in India is done by multinationals in comparison to Indian firms. However, Indian ICT firms, especially those in the services domain, had experimented with products. Almost all the leading domestic software firms had products in their offering when they started operations. The focus on the product segment lost steam as the growth of the domestic industry was inadequate, the distance from end users in foreign markets was long, funds were lacking to market the products and heavy expenditure was needed to evolve the product according to market demands (Athreye, 2005; Sharma, 2008). In addition, the high demand for software services in the US resulted in Indian firms shifting their focus to the export services domain. Hence, innovation among Indian firms is process innovation that enhances service delivery efficiency.

2.2. ICT scoreboard – top 20 firms

List of top twenty firms in terms of revenue offers interesting insights. Of these firms, 12 are multinational firms out of which one was started by the Indians, Cognizant Technology Solutions. First three spots are captured by Indian firms who generate revenues predominantly from exports of software services and only one is an exclusive ICT firm, Infosys. The leader Tata Consultancy Services is one the leading business group in the country with presence in almost all business domains. As mentioned earlier, innovation systems are led by the multinationals. Indian firms make very little investment on R&D-related activities.

Table 18: Top 20 firms in terms of revenue

Rank	Name of the company and location	Starting year	Products and services	Employees	Revenue (million Rs.) 2007– 08	Remarks
1	Tata Consultancy Services (TCS), Bangalore.	1968	Software services, IT consulting, and BPO	126,150	212,150 (93% export and 7% domestic)	The spurt in R&D as the number of patents filed by the company more than doubled to around 58. Bought Citibank's BPO arm, e-serve, for $505 mn. Consolidated its operations in Eastern Europe, the Middle East, Africa, and Latin America
2	Wipro Technologies, Bangalore	1981	IT services, product engineering services, technology infrastructure services, consulting services, BPO	108,071	168,840 (76% export and 24% domestic)	Wipro is one of the world's largest independent R&D services providers Among the top 3 offshore BPO service providers in the world. Wipro is a strategic partner to five of the top ten most innovative companies in the world.[13]
3	Infosys Technologies, Bangalore	1981	IT services, IT products, BPO, consulting	104,850	155,310 (99% export and 1% domestic)	Partnered with University of Cambridge for strategic research. Invested $1.9 mn for R&D effort in Australia.
4	HP India, Bangalore	1989	Enterprise servers, software & storage, hardware, imaging and printing, IT services & solutions	31,656	154,540 (18% export and 82% domestic)	Penetrated deeper into Class C and D cities by launching mobile vans, and linking them with channel networks. Electronic Data Systems Corp. (EDS) acquisition helped it leverage the domestic market better– in terms of new capabilities in manufacturing, transportation, PSUs, healthcare, as well as infrastructure management and BPO .

[13] Technology Review Innovation Index 2005.

Rank	Name of the company and location	Starting year	Products and services	Employees	Revenue (million Rs.) 2007– 08	Remarks
5	IBM, Bangalore	1992	IT services, BPO, servers, storage, middleware, and systems software	76,000	101,010 (of which 58% export and 42% domestic)	Its India research also got global visibility with key initiatives such as the spoken web. It continued to lead the industry in terms of diversity programmes and CSR initiatives.
6	Cognizant Technology Solutions, Chennai	1994	IT Services and BPO	48,000	63,100 (100% export)	Acquired Active Intelligence, a small SI company specialising in Oracles retail solutions portfolio Entered into a multi-year partnership with HealthNet Launched Touchstone Centre in Bangalore to demonstrate SOA support for SAP solutions
7	Ingram Micro, Mumbai	1996	Distribution of IT products and consumer electronics	1,200	86,200 (100% domestic)	A large array of product lines in the offing, a result of tie-ups with almost all leading IT vendors A well-established partner network across India that emerges stronger each year
8	HCL Technologies, Noida	1991	Software, infrastructure, and BPO	51,979	62,000 (93% export and 7% domestic)	Launched its business-aligned R&D campaign to reinforce leadership in manufacturing space. Launched GoPro, its soft-skills programme. Launched its Enterprise Transformation Services, promising tangible cost savings priced on revenue share or outcome-based model.
9	HCL Infosystems, Noida	1976	Computers, storage systems, managed systems, infrastructure, office automation, software and network integration	6,077	50,580 (100% domestic)	HCLI entered the physical security space and launched Safe State, a 100% subsidiary, to offer SI solutions around security and surveillance. Still very low market share (11– 13%) in the PC/Laptop market.
10	Redington India, Chennai	1993	Distributor of PCs, servers, peripherals, consumables, and networking equipment and components	1,700	62,800 (100% domestic)	Redington put in place its Automated Distribution Center (ADC) in Chennai that significantly improved its warehouse space management capabilities.
11	Cisco India, New Delhi	1995	Networking	4,850	58,370 (92% export and 8% domestic)	Leveraging India's networking talent pool effectively. Good success in the government sector.
12	Oracle India, Gurgaon	1993	Database, middleware, application software	24,000	58,080 (N.A.)	10 acquisitions made during the year. Continues to retain a huge market share in the database business.
13	Intel India, Bangalore	1988	Processors, platforms, boards, R&D	2,500	43,100 (90% export and 10% domestic)	Global R&D spend remained flat thereby impacting the Indian centre, being one of the largest. Flat spending on R&D did not deter the India team from contributing to global product initiatives like Dunnington, Montevina, and Nehalem server.
14	Accenture, Bangalore	1987	IT services & Consulting	40,000	38,000 (93% export and 7% domestic)	Got serious about domestic business by reorganising domestic team to reflect the global approach.

Rank	Name of the company and location	Starting year	Products and services	Employees	Revenue (million Rs.) 2007– 08	Remarks
15	SAP India, Bangalore	1996	Packaged Software and services	5,424	32,600 (79% export and 21% domestic)	Started SAP Ventures for corporate innovation and invested for minority stake in Newgen Software. Gained very good ground in chemicals and utilities.
16	Dell India, Bangalore	2000	Desktops, Laptops, and servers & storage	13,000	32,000 (100% domestic)	Great potential in the consumer market with a wide range of models, colour range, and an option of placing customised orders.
17	Tech Mahindra, Pune	1986	Software services & BPO	24,318	36,370 (98% export and 2% domestic)	Shift in onshore-offshore ratio towards offshoring, meaning that company is able to better leverage its centres in Pune, Mumbai, Bengaluru, Noida, Kolkata, Chandigarh, Chennai, Hyderabad, etc.
18	Microsoft India, Gurgaon	1981	IT services, software & consulting	5,300	32,630 (90% export and 10% domestic)	Still the undisputed leader in consumer OS with Windows, further strengthened with Windows 7 launch. Launched controlcost.com to attract enterprise customers
19	MphasiS, Bangalore	1992	IT services, BPO	33,810	18,810 (100% export)	Strong partnership with and leadership from HP-EDS, has demonstrated great results on performance side.
20	Patni Computer Systems, Mumbai	1978	Application development, infrastructure management services, BPO, engineering design & embedded systems	14,479	25,690 (99% export and 1% domestic)	On the people front, it tied-up with leading US universities to train employees in the area of innovation and IP-led services. It also launched Patni Learning Edge (PLEdge), an industry-academia collaboration focusing on graduate colleges in Mumbai.

Source: Dataquest, 2009. http://dqindia.ciol.com/dqtop20/2009/CompanyRanking/default.asp (accessed 8 May 2010).
Note: Data was given voluntarily by the firms to Dataquest. The composition may differ from the NASSCOM data where detailed information on firms is not given.

We selected two case studies: Tata Consultancy Services (TCS) and Texas Instruments (TI). TCS is an Indian ICT company and part of a large business conglomerate, TATAs, which recently launched a USD 2300 car called NANO. TCS is one of the early ICT firms in India that successfully leveraged the software outsourcing model in the world. TI was one of the first multinational companies to establish a development centre in India. TI still leads the number of patents filed by a firm located in India. TI's success in exploiting local high-skilled labour served as a catalyst for many multinational firms to enter India. Both cases are presented in Appendix C.

3. ICT R&D: INTERNATIONALISATION

According to Technological Information Forecasting and Assessment Council (TIFAC) between 1998 and 2003 the total R&D-based FDI to India was $1.13 billion (TIFAC, 2006). More than 100 of the Fortune 500 firms had established R&D facilities or relationships in India by 2003. By 2007 more than 250 Fortune 500 companies have forged some R&D links with India. Of these, 150 have established global R&D centres in India (Satyanand, 2007). FDI in R&D has more than doubled since 2003 and now amounts to 25% of the total FDI inflow. Transnational Corporations (TNCs) from the US have invested more than 70% of the total, followed by South Korea, Germany, Denmark, and the UK. A recent study by the EU revealed that most of the R&D projects from EU countries that went abroad have gone to India, followed by China and far ahead of the US and other countries (Tiwari, 2007). FDI in R&D is largely concentrated in software and IT services, but more FDI is targeting chemicals and related sectors such as molecular chemistry, biopharmaceuticals, and automotive and engineering sciences. A number of new R&D investments (in the range of $80m to $250m) were announced in 2005–2006 in the telecom and networking sector by companies such as Alcatel, Ericsson, EMC Elcoteq, Flextronics, Nokia, Samsung, and Siemens (Mitra, 2007).

The types of foreign R&D in India include (i) in-house R&D by TNC affiliates; (ii) collaboration with other companies (mainly in the software industry); and (iii) contracts or other forms of relationships with private entities, public laboratories and universities (e.g. the biotechnology industry) (Mitra, 2007). Unlike in the past when TNCs set up R&D facilities to support their production units, in the current phase they are opening independent dedicated R&D centres to undertake R&D in new and emerging high-tech areas. A number of TNCs such as Texas Instruments, Motorola, Intel, and Microsoft have established R&D facilities in software and IC design. Intel and Cisco have announced investments of over $1 billion over the next five and three years, respectively, Microsoft announced an investment of $1.7 billion and IBM $6 billion (Mitra, 2007; Mrinalini and Wakdikar, 2008). GE's John F. Welch Technology Centre in Bangalore employs over 2,200 scientists, researchers and engineers (the second largest of GE's global research teams). What is interesting is that the R&D units of TNCs in India are mostly stand-alone units with no production or marketing base in India. TNCs also forged non-equity-based strategic partnerships with Indian research institutions (particularly in the area of pharmaceuticals and chemicals) and firms (the IT industry). Another interesting development is that not only TNCs but also small and medium enterprises (SMEs) have started R&D operations in India (Mitra, 2007).

3.1. The role of FDI in ICT R&D trends

An analysis of data on total foreign direct investment (FDI) shows that, during 2000– 2009, out of USD 92,158 million, Mauritius is the top investor with USD 43,143 million (44%), followed by Singapore (8,667; 9%) and the US (7,443; 7%). Mauritius has double taxation avoidance agreement with India,[14] by which income is taxed in only one country. Apart from this investor-friendly policy, Mauritius has the advantage of being geographically close to India.

Among the various sectors, the services sector – financial and non-financial – dominates, with USD 21,728 million (23%) followed by computer software and hardware (9,334; 10%)) and telecommunications (8,120; 8.2%) (DIPP, 2009). There is a possibility that FDI in the ICT

[14] For further details, see: http://business.gov.in/outerwin.php?id=http://incometaxindia.gov.in/mappop.htm

sector can include R&D sub-sectors, but this is not reported by the firms. There is no mechanism in the Indian government statistical framework to capture this information.

Foreign direct investment (FDI) followed three successive stages in India. In the 1980s, the first set of firms came to India to exploit the local market. For instance, Suzuki (Japan) was the first major automaker to collaborate with the Indian government, followed by all major players of the world. The second stage, in the early 1990s, saw the entry of large software houses in India, either directly or through joint collaborations driven by the globalisation of the ICT industry. The third stage, in early 2000, is marked by the entry of R&D centres being established by already entered players or new players (TIFAC, 2006). IBM and Microsoft starting its research labs in addition to its existing software development centres is an example of the third stage.

In 1998–2003, in the list of the top 100 firms by R&D investment and country analysed by the Technology Information Forecasting and Assessment Council (2006, p.5)), the US leads the list with 53 firms followed by UK, Japan and Germany with seven firms each. Other countries that have a presence are Switzerland, Sweden, South Africa, Norway, the Netherlands, Mauritius, Denmark, Canada and Australia During the same period, R&D investment worth USD 1.13 billion flowed into India. The cost of high-skilled personnel is relatively lower than in industrialised countries. It is estimated that an entry-level top scientist can be hired for USD 10,000 per year.

Irrespective of the technological domain, Bangalore is the preferred location among investors. The bulk of the R&D investment entered India during the period 1999–2001. Among the activities performed by the R&D units, offshore R&D for in-house R&D leads the pack (53 cases), followed by R&D exports and domestic marketing (23 cases) (TIFAC, 2006).

Among the ICT firms that invest in R&D centres in India, the US dominates. An attempt to understand the nature of ICT R&D centres in India reinforces this opinion. Investment from European Union countries is very low (Table 19).

Table 19: Country location of headquarters of ICT R&D centres in India

Country location of Headquarters	Percentage
Austria	0.6
Brazil	0.6
Canada	0.6
China	0.6
Finland	0.6
France	3.8
Germany	3.8
Israel	0.6
Japan	3.1
Netherlands	1.2
Singapore	0.6
South Korea	3.8
Sweden	1.2
Switzerland	1.2
Taiwan	0.6
Turkey	0.6
UK	3.8
USA	72.5
Total	100 (N=160)

Note: Data compiled by Ilavarasan (2010). Total number of R&D centres of ICT MNEs was arrived at by searching material available in the CMIE database, Trade press, DSIR database, and TIFAC database.

There are multiple reasons for the US dominance in the number of R&D centres. The US is the major consumer of software services that originate from India. Firms that explored the Indian market for offshoring are from the US. Also, historically, high-skilled Indians migrated to the US for higher studies, and later stayed to work in the high-technology sector. Reverse migration of Indian immigrants, who connected the demand in the US with the supply in India through their professional networks and understanding of market and technology, helped the industry cement the sector linkages between the US and India in the ICT sector (Saxenian, 2002; Sharma, 2009). Apart from market conditions, English is an important reason. Indians' exposure to English at the school level is instrumental in bringing US customers closer to them compared to other languages in the world.

Non-US firms coming to India, either to offshore or to invest in R&D centres, have generally followed US firms after observing the demonstration effect of the successful US-based multinationals. An analysis of secondary data showed that most multinational firms come to India to use the low-cost high-skilled labour and continue working on activities delegated by their headquarters. Over time, the India centre gains confidence and starts undertaking high-skilled work from the parent firms (Ilavarasan, 2006; 2010). Also, India offers a strategic location as it is close to emerging markets like the Middle East countries and East Asian countries (Engardio, 2008).

On the nature of activities performed in the R&D centres of ICT firms – adaptation to the local market or design and development of products for foreign markets – Ilavarasan (2010) offers some insights. He uses the conceptual framework by Archibugi and Pietrobelli (2003) which broadly classifies R&D centres of MNEs in host countries into three categories:

> "Center-for-global (This is the traditional 'octopus' view of the TNC [Transnational Corporations, which are defined as MNEs in this study]: a single 'brain' located within

> the company headquarters concentrates the strategic resources: top management, planning, and the technological expertise. The 'brain' distributes impulses to the 'tentacles' (that is, the subsidiaries) scattered across host countries. Even when some overseas R&D are undertaken, this basically focuses on adapting products to the needs of the local users; Local-for-local (Each subsidiary develops its own technological know-how to serve local needs. The interactions among subsidiaries are, at least from the viewpoint of developing technological innovations, rather weak. On the contrary, subsidiaries are integrated into the local fabric. This may occur with conglomerate firms, but also in the case of TNCs which follow a strategy of technological diversification through tapping into the competence of indigenous firms) and Local-for-global (This is the case of TNCs that, rather than concentrating their technological activities in the home country, distribute R&D and expertise in a variety of host locations. This allows the company to develop each part of the innovative process in the most suitable environment: semiconductors in Silicon Valley, automobile components in Turin, software in India. The effectiveness of such a strategy relies on intense intrafirm information flows) (p. 878)"

Using content analysis of secondary material available on 160 sample firms, Ilavarasan (2010) classified the R&D centres into these three categories. Centres which stated that the quality of manpower available in India is good enough to use as a base for executing designs made in the home country result in India as a cost centre. Activities performed in the centre typically cater to the global market. These centres are centre-for-global. The second set of centres is established to tap into the huge local market. These centres adapt their product to local needs like developing software in Indian languages or providing services to telecom players. This shows their intention to exploit the Indian market by adapting their product to local needs in India. Some of the companies have stated that this is to expand the company's presence in India. These centres use local talent to come up with products for the local market. These centres can be called local-for-locals. Third set of centres are established as part of a strategic decision and complement the global technology development effort of the MNEs. These centres work on "mainstream research" by the parent firms. Some companies even say that their India R&D centre now contributes to the development of all major products in their areas of business. Such R&D centres are classified as local-for global.

The R&D centres of IT MNEs appear to be divided into two halves, with 50% serving as center-for-globals and 46% as local-for-globals. A small number of centres, 4%, are established as local-for-locals (Ilavarasan, 2010).

The nature of R&D centres suggests the level of critical work happening in India and the importance of India in the global strategy of IT MNEs. Center-for-globals, though the value is much higher than in the typical offshoring software services centres, operate on the labour cost arbitrage model, specifically with respect to high-skilled labour. Control of the project activities still lie with the parent firms. In contrast, in local-for-globals, the Indian centre becomes an equal partner which is likely to share responsibility for product development activities. The transition from center-for-globals to local-for-globals indicates the growing importance of India as an important location for technological activity. National technological capabilities are enhanced multi-fold when the value of activities performed in the R&D centres increases. It also disseminates the MNE's expertise locally. As the number of local-for-global centres increases, opportunities to serve the global market in the product segment open for the Indian workforce through domestic partners. The third set of centres, local-for-

locals uses the local workforce to develop products for the local market which is not fully exploited by the domestic firms. Some of the innovations from India are given in Table 20.

Table 20: Innovations from MNCs in India

Area	Examples of Innovation
New Technologies	• Inter Dunnigton – The world's first 6-core CPU • Adobe Premiere elements – video editing software • CISCO emergency transponder • TI-LoCosto – World's first single ship platform • Google India transliteration
Business Applications	• Google Finance • Finnacle / Flexicube • Adventnet Zoho • Oracle 10g
Business Model and Process Innovation	Mindtree's knowledge enterprise solution

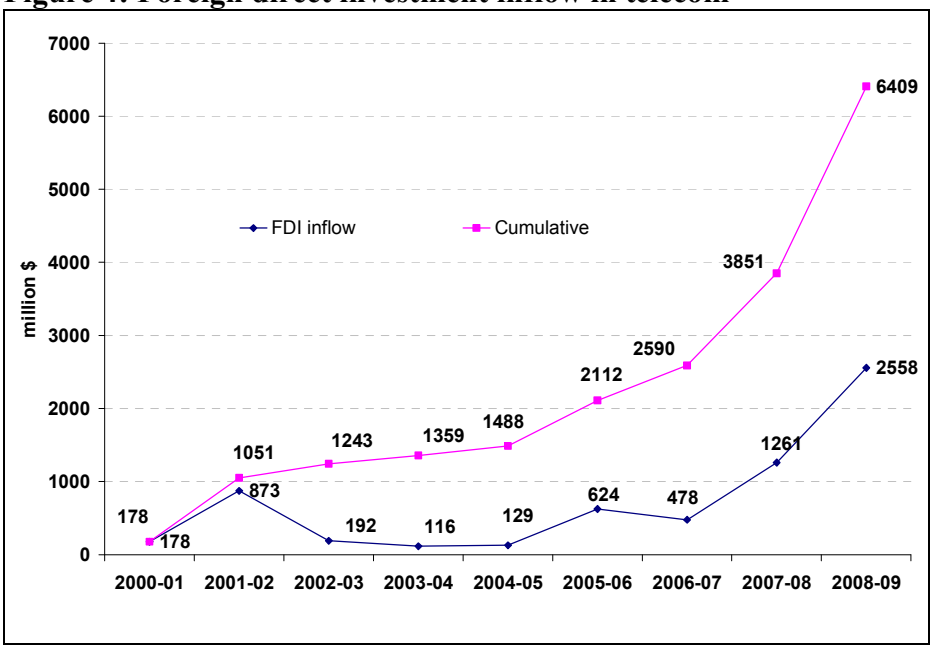
Source: NASSCOM, 2009.

Most of the centres start as centre-for-global to shape up as local-for-global and the transition is gradual. The India centre has to prove its worth by executing projects in the initial phase to win the confidence of the parent firm. R&D centres in India work in complete integration with the parent companies, using travel, video conferencing, email, and online chat. There are two models of integration. In the first model, the parent company identifies the appropriate skill availabilities in different R&D centres all over the world and puts them together for a project. The second model is where the India centre is given complete responsibility for one domain and works more or less independently. Patents are an important indicator of the technological outputs of innovation systems.

The study also tried to understand whether Indian centres received patents in their names. In the secondary data, three-quarter of the centres claimed or reported that the India centre is responsible for a certain number of patents filed. However, a closer analysis at the secondary data showed that the patents are not filed in the name of the India centre; as a policy, MNEs file the patents in their parent countries without crediting any of the host countries. However, Indian researchers who have contributed to the invention or discovery are acknowledged in the patents. Indian researchers are given rewards in terms of promotions, monetary benefits and firm-level awards. However, none of the representatives said that the researchers share the revenue generated from the patents (Ilavarasan, 2010).

In the case of telecoms, the growth is driven by domestic investment, with only USD 3.85 billion coming from FDI between 2000–01 and 2008-09 (Figure 4) (for company approval of FDI in telecom, see Appendix A and B). The FDI in telecom was around 5% of the total telecom investment in 2006–07. Unlike many countries in the region, FDI in telecom accounted for only 5.17% of the total FDI flows to India in 2007–08, which rose to 9.54% in 2008–09 (Table 7).

Figure 4: Foreign direct investment inflow in telecom



Source: Fact sheets on FDI, Department of Policy & Promotion (DIPP), and Department of Telecommunication, Ministry of Communication and Information Technology, Government of India.

Panoramic view on limits under FDI regime:[15]

1. Up to 74% (49% under automatic route) for Basic and cellular, UAS, NLD/ILD, V-Sat, PMRTS, GMPCS and other value added services;
2. Up to 74% (49% under automatic route) for ISP with gateways, radio-paging, end-to-end bandwidth;
3. Up to 100% (49% under automatic route) for ISP with gateways; electronic and voice mail; IP category 1;
4. Up to 100% for manufacture of telecom equipments.

3.2. Asian R&D offshoring

Over the past two decades, government policy in India relating to outward FDI has made a palpable transition from a cautious and restrictive approach to one of facilitation and encouragement. Outward FDI is now considered an effective tool for economic advancement through harnessing global technological know-how, building trade support networks to enhance the international competitiveness of local firms, and opening new market channels for promoting exports (Government of India, 2009).

Overall Indian investment in foreign countries either as joint ventures or wholly-owned subsidiaries has not been small. India's FDI outflow was USD 18.7 billion in 2007. India's FDI outflows had increased by 26.5% in the period 2004–2005. Thereafter, the growth rates shot up to 169.4% in 2005–2006 and further to 173.1% in 2006–2007. The annual average growth in India's actual FDI outflows growth worked out to 100.9% which was much higher than the growth in global FDI outflows (Reserve Bank of India, 2009, p.1142).

[15] Adopted from: KPMG, DoT and FICCI, 2009, *The Indian Telecom Success Story*, Indian Telecom 2009, New Delhi, India.

The manufacturing sector has been the leading contributor to FDI outflows. Of the cleared proposals for FDIs, manufacturing constituted 42% in the total amount proposed, worth USD 21.8 billion in 2007–2008 and 47% of total USD 21.03 billion in 2008–2009. Non-financial services where software development is grouped with others like oil exploration, power generation and consultancy constituted 11% in 2007–2008 and 8% in 2008–2009 (Reserve Bank of India, 2009).

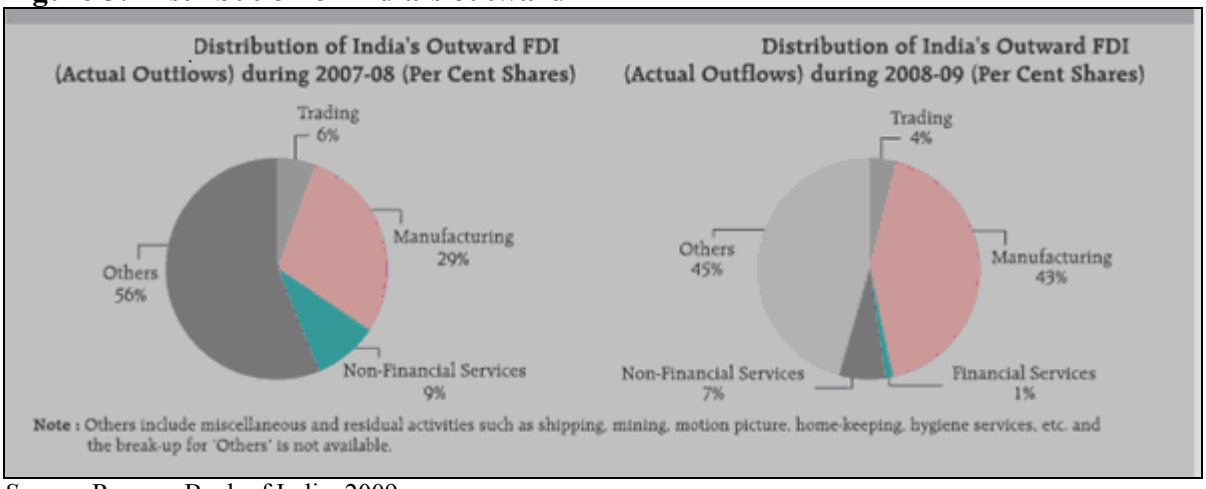
The distribution of actual outward FDI in 2008–09 indicated that 43% of the total proposals was in manufacturing, followed by non-financial services (7%), trading (4%), financial services (1%), and the balance was 'others'. During 2007–08, 29% of the total proposals was in manufacturing, followed by non-financial services (9%), trading (6%) and the rest was 'others'. The pattern of investment proposals during 2008–09 reveals an increase in the shares of manufacturing and financial services and a decline in the shares of non-financial services and trading (Reserve Bank of India, 2009, p.1150).

Table 21: Sectoral distribution of India's outward FDI – actual outflows (US$ million)

Sector	2007–08 April–March	2008–09 April–March
Trading	1050.1	640.1
Manufacturing	5408.9	6817.0
Financial services	88.4	174.9
Non-financial services	1747.8	1068.0
Others	10453.9	7247.8
Total	17749.0	15947.8

Notes: 1. Data are provisional.
2. 'Others' includes miscellaneous and residual activities such as shipping, mining, motion pictures, home-keeping, hygiene, services, etc. The break-up for 'Others' is not available.
Source: Reserve Bank of India, 2009.

Figure 5: Distribution of India's outward FDI



Source: Reserve Bank of India, 2009.

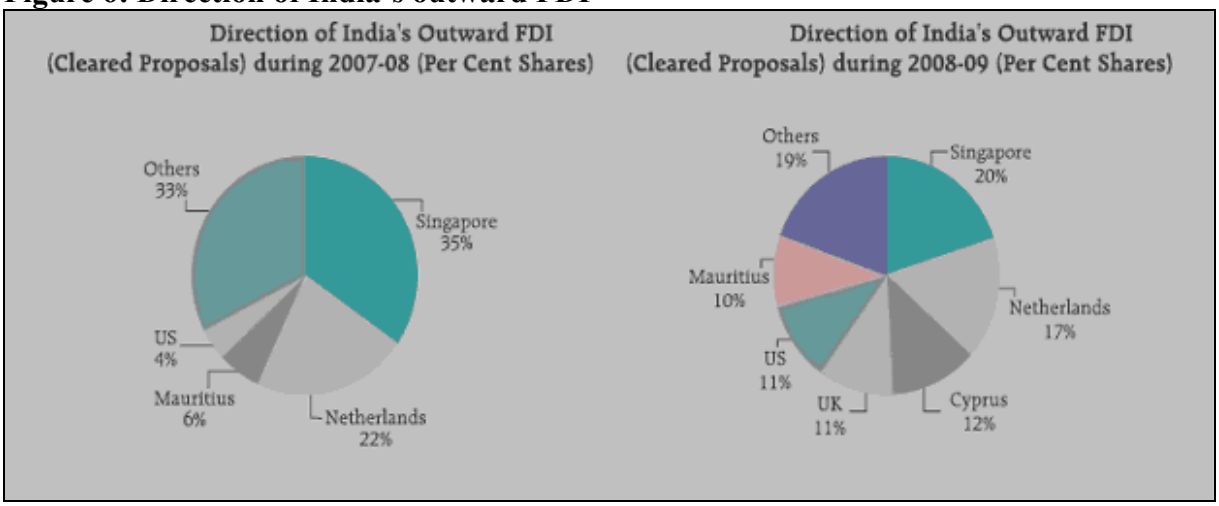
Among the recipient countries for proposals that were cleared during 2008–2009, Singapore, the Netherlands, Cyprus, the UK, the US and Mauritius accounted for 81%. In 2007–2008, Singapore, the Netherlands, Mauritius, and the US accounted for 68% (Table 22) (Reserve Bank of India, 2009).

Table 22: Direction of India's outward FDI (cleared proposals) (US$ million)

Country	2007–08		2008–09	
	January–March	April–March	January–March	April–March
1	2	3	4	5
Singapore	1194.7	8350.5	1300.8	4255.0
Netherlands	295.7	5341.1	300.4	3530.6
Cyprus	429.4	661.4	2358.4	2629.0
UK	224.2	543.4	78.4	2344.2
USA	224.2	1052.9	238.7	2302.0
Mauritius	603.6	1478.6	425.1	2049.1
UAE	424.8	617.2	162.9	908.7
Switzerland	18.0	478.3	44.6	343.2
Australia	18.1	38.2	168.9	302.8
Denmark	-	497.6	-	278.4
Others	1093.2	4697.9	473.0	2277.7
Total	4525.9	23754.1	5551.2	21220.7

Note: Figures related to investments of US$ 5 million and above.
Source: Reserve Bank of India (2009).

Figure 6: Direction of India's outward FDI



Source: Reserve Bank of India, 2009.

Given the poor focus on the domestic sector as a whole and the hardware sector in particular, investments by Indian ICT firms might be in the area of services and might be much lower than in other industrial sectors. There are no data sources from government sources on estimating the value contributed by the ICT sector in terms of outward investment.

A trade association report (NASSCOM, 2009) says that the contribution of the Indian ICT sector in outward FDI, measured through values of merger and acquisitions (M&A), is significant with 11% in 2008, which was doubled from 2007. In 2008, the total number of deals involving Indian ICT firms increased by nearly 17%, which is USD 3.4 billion from USD 2.9 billion in 2007. However, the number of deals declined from 159 to 98, indicating a higher average deal size in 2008, i.e., USD 32.38 million compared to USD 18.15 million in 2007.

Some of the M&A deals are the following (NASSCOM 2009, p.76):

- HCL Technologies acquired UK consulting firm, Axon, for USD 658 million.
- TCS bought Citi's BPO for USD 505 million.

- Wipro took over Citi's Technology Services for USD 127 million.
- 3i Infotech acquired US-based Regulus Group for USD 80 million.

Table 23: M&A fact sheet for 2003–04

Investor Company	Invested Company	Size of deal
Datamatics Technologies	CorPay Solutions (US)	$9 mn
ICICI OneSource	FirstRing (India)	-
Hinduja TMT	c3 (Philippines)	$3.9 mn
Zensar	Suntech Data Systems	$0.7 mn
B2K Corporation	Talisma (technical outsourcing service)	-
WNS	ClaimsBPO (US)	-
Lawkim	Upstream LLC (US)	$6 mn
TCS	Airline Financial Services (India)	$5.8 mn
Essar	Aegis Communications Group (US)	$28 mn
Indian Rayon	Transworks (India)	$13 mn
Mascot	IT&T	$4.5 mn
Perot Systems	Vision HealthSource	$10 mn
MedusInd Solutions	SRF Infotech (India)	-
iGate	Quintant Services	$19.9 mn
Ismart	L&L Services	$0.9 mn
Optimus (Polaris)	iBackOffice	-
Citigroup	e-Serve	$122 mn
IBM*	Daksh	$150 mn
Partnerships/JVs		
Msource (Mphasis)	Accenture	Partnership
Infowavz	Contact Power Inc. (UK)	Partnership
Sutherland Group	ISANI Group (US)	Partnership
L&T Infotech	ACS	Partnership
Tracmail	Webhelp; Spherenomics	JV; formed new company TWS Holdings
Datamatics Technologies	Cadmus	JV; formed new company KnowledgeWorks Global Ltd
Bharti	TeleTech Holding	JV; formed new company TeleTech Services
ITC Infotech	ClientLogic	JV; formed CLI3L

Source: Dataquest, http://dqindia.ciol.com/dqtop20/2004/giants/bpo3.htm (Accessed on April 25, 2010)
Note: *Announced in 2004–05.
Since March 31, 2004 not only has IBM acquired Daksh, but even Stream has acquired a certain stake in Infowavz. Except for Daksh, none of the other arrangements can be described as mega-deals. TCS looks likely to consolidate all its BPO operations under one umbrella that could include Intelenet, AFS as well as Phoenix Global Solutions.

Table 24: 2005 M&A dossier for Rs 1000 crore+ (US$ 223+ mn) companies[16]

Nature of Deal	Deal Financials
TCS	
Acquired Financial Network Services (FNS)	$26 mn
Acquired Comicron	$23 mn all-cash deal
Acquired life insurance and pensions BPO division of Pearl Group	$101 mn to be paid over four years for more than 75% stake in the JV
Formed JV company, C-Edge Technologies	Starting with an authorised capital of Rs 40 crore
Tata Infotech merged into TCS	A stock swap whereby shareholders of Tata Infotech received one equity share of Re 1 each of TCS for two equity shares of Rs 10 each
Wipro	
Acquired mPower and MPACT Technology Services, a JV between MasterCard and mPower.	$28 mn all-cash deal
Acquired NewLogic	$56 mn in all-cash deal
Satyam	
Acquired Citisoft	Guaranteed payment of $23.2 mn payable over a three-year period and an additional performance-based payment of up to $15.5 mn, also to be paid over a three-year period.
HCL Technologies	
Acquired AnswerCall Direct	$6.5 mn
Acquired the remaining 16.3% stake in HCL Enterprises Solutions (HES)	-

Source: http://dqindia.ciol.com/content/industrymarket/focus/2006/106021004.asp (Accessed 25 April 2010).

Table 25: 2005 M&A Dossier for Tier 2 (Rs 300–1000 crore) Companies (US$ 67–223 mn companies)

Nature of Deal	Deal Financials
MBT	
Acquired Axes Technologies	$54 mn in an all-cash deal
MphasiS	
Acquired Princeton Consulting	$14 mn all-cash deal
Acquired Eldorado Computing	$16.5 mn all-cash deal
Zensar	
Acquired OBT Global	All-cash deal but size of transaction not revealed

Source: http://dqindia.ciol.com/content/industrymarket/focus/2006/106021004.asp (Accessed on 25 April 2010).

[16] Average exchange rate of 2005 is used to convert all the figures. Exchange rate Rs. 44.9315=US$ 1.

Table 26: 2005 M&A dossier for tier 3 (<Rs 300 crore)c Companies (<US$ 67 mn companies)

Nature of Deal	Target Company History	Deal Financials	Strategic Implications
KPIT Cummins			
Acquired SolvCentral	This Washington-based BI solution vendor grossed revenues of $3.5 mn	$2 mn in cash and stock	Strengthens KPIT's BI practice by creating a new LoB and bolsters its US presence
Acquired Pivolis	A Paris-based company providing offshore consulting services using Agile Offshore Software Development Methodology and grossing a revenue of 3.5 mn	$2.25 mn comprising 50% cash and 50% stock	Strengthens KPIT's presence in the BFSI vertical and opens up the French-speaking European market
Tata Technologies			
Acquired INCAT Technologies	This $120 mn UK-based vendor offers engineering and design services as well as PLM products and services.	$93 mn cash deal.	Bolsters Tata Technologies offshore capabilities in engineering automation with its high-end onshore strengths and brings customers such as DaimlerChrysler, Ford, Lotus, Grumman, Honda, Magna, Steyr, and Boeing.
Aztec Software			
Acquired Disha Technologies	This Rs 14.14 crore company provided independent testing services	Around $12 mn.	Enables Aztec to offer testing services.
Geometric Software			
Acquired Teksoft	Oncourse Technologies sold two of its subsidiaries, TekSoft and Cimtronics, based in Scottsdale, Arizona.	Around $3 mn	Enhanced Geometric's desktop product portfolio by bringing in ProCAM and CAMWorks suite of products.
Subex Systems			
Acquired Fraud Management division of Alcatel and Fraud Centurion product of Lightbridge	Fraud Centurion brings 14 new clients.	Around $3 mn	Bolsters Subex's fraud management portfolio and adds new clients in the US.
3i Infotech			
Acquired SDG Software Technologies.	This Hyderabad-based Rs 10 crore company offers products for banking and capital markets with a focus on surveillance and fraud	NA	The BankAlert AML product fills a gap in 3i's banking product portfolio.

	management.		
Acquired FormulaWare	This US-based software vendor provides ERP solutions for the process manufacturing industry.	NA.	Extends 3i offerings among SMEs in the lubricants, paints, inks and glues process manufacturing industries.
Mindtree Consulting			
Acquired Linc Software	Bangalore-based Linc Software focuses on ERP product support and web development with clients such as Unilever, Atlas Copco, Emerson Group, and Novartis.	Around $12 mn.	Enables MindTree to strengthen its capabilities in the IBM i-Series space.
Helios & Matheson			
Acquired vMoksha Technologies	Bangalore-based $22 mn vMoksha group comprised vMoksha Technologies, vMoksha Technologies USA, and vMoksha Technologies Singapore.	$17 mn cash and $2 mn based on targets achieved over two years.	Allows Helios to expand client base in BFSI and healthcare.
Foursoft Technologies			
Acquired CargoMate	This Dutch company has been engaged in logistics-related services for the past 14 years, supporting the shipping and cargo industry in the Europe with about 50 customers.	Transaction of $1.9 mn.	Enables Foursoft's foray into Europe with a subsidiary.
Tata Interactive Systems			
Acquired Tertial Edusoft AG in Switzerland from the Germany-based Tertia Group, a provider of human resource management solutions	Tertia Edusoft AG is the market leader in Switzerland in the development of regulatory and compliance training solutions for the BFSI, professional services, logistics and telecom sectors.	NA.	Enhances Tata Interactive's global footprint and widens its offerings in Europe.
Acquired Tertia Edusoft GmbH in Germany also from the Tertia Group	Tertia Edusoft GmbH's core competence in Germany lies in providing management simulations, through their proprietary product line, TOPSIM, used by more than 1,000 customers.	NA.	TOPSIM range works in synergy with Tata Interactive's strong global presence in the simulations segment.

Source: http://dqindia.ciol.com/content/industrymarket/focus/2006/106021004.asp (Accessed on 25 April 2010).

While Indian companies expanded into geographies other than the US, the pace was somewhat muted (NASSCOM, 2009, p.76). Trade press reports indicate that acquisitions of foreign firms are getting difficult for Indian firms, especially in Europe (see, for instance, Mishra and Thimmaya, 2009). Though Indian firms are willing to undertake the acquisition route for growth (Economic Times, 2009) they face challenges in terms of differences in valuation and culture.

In the ICT sector M&A deals differ depending on the size of the firm. Large firms acquire firms because they need niche domain expertise for their current offering; achieving significant scale is not their priority. Second-tier firms acquire firms both to achieve larger scale of operations and to gain niche expertise. The third set of smaller firms looks for similar smaller players to enhance their niche technology strength. Apart from strengthening the variety of niche technology domains, Indian firms also use acquisitions to diversify into different geographical domains. Acquisitions are typically made in the software development and semiconductor design areas, followed by the associated business processing domains (De, 2006). A trade press magazine offers insights along similar lines as explained above (in Table 25).

Table 27: Recent mergers and acquisitions

Company	Merged with/Acquired	Reason/Benefits
Polaris	Merged with OrbiTech	Acquired IPR of OrbiTech's range of Orbi banking product suite.
Wipro	Acquired Spectramind	Aimed at expanding in the BPO space. The acquisition gave Wipro an opportunity to run a profitable BPO business.
Wipro	Acquired global energy practice of American Management Systems	Acquired skilled professionals and a strong customer base in the area of energy consultancy.
Wipro	Acquired the R&D divisions of Ericsson	Acquired specialised expertise and people in telecom R&D.
Wipro	GE Medical Systems (India)	Acquired IP from the medical systems company, which in turn gave it a platform to expand its offerings in the Indian and Asia Pacific healthcare IT market.
vMoksha	Challenger Systems & X media	Primarily aimed at expanding its customer base. The company also leveraged on the expertise of the companies in the BFSI space.
Mphasis	Acquired China-based Navion software	Expanded its presence in the Japanese and the Chinese markets. It also plans to use it as a redundancy centre for its Indian operations.
Mascot Systems	Acquired US-based eJiva and Hyderabad-based Aqua Regia	Expanded in size and leveraged on technical expertise of the acquired companies. Acquisitions have helped the company in offering multiple services and expanding its customer base considerably.

Source: http://www.expresscomputeronline.com/20030407/indtrend1.shtml (Accessed on 25 April 2010).

Though Indian firms are expanding their global reach and technology domains in service through acquisitions, it is difficult to conclude that R&D capabilities have been acquired. Indian firms continue to cater to western clients in terms of software product development or engineering services and innovate for in-house consumption, rather than developing

standardised products for open markets. Though some of the acquisitions are said to provide R&D capabilities to Indian firms, hard evidence in terms of patents or revenue earned through licences is not present. For instance, Wipro, a top 10 ICT firm, acquired an Austrian firm Nerve Wire and a US-based firm, mPower, in 2003. Nerve Wire provided access to European markets in addition to technological capabilities in communications, WLAN and blue tooth. mPower gave domain expertise in the e-payment space and strengthened its market offerings in the US (De, 2006).

Indian firms gain access to foreign markets and R&D capabilities by acquiring captive Indian units of foreign firms (see Table 25). A recent trade press showed that at least 15 such Indian R&D centres of multinationals were acquired by Indian firms.

> "Symphony Services has acquired close to seven companies while Global Logic has acquired about four. HCL, Persistent, L&T and others have acquired one each in the R&D sector. The captive centres acquired are as follows: Symphony Services – In-reality, Intransa, CT Space, Cambridge Tech Partners; GlobalLogic India - Mantas India, Validio Software, Kewill Software Solutions, Praedea Solutions; HCL Technologies - Adaptec India; Persistent Systems - Metrikus; and L&T Infotech - GDA Technologies."
>
> (M. Sharma, 2009).

M. Sharma (2009) quotes an industry representative for the reasons for such transactions in the industry:

> "These centres were part of the parent company doing R&D in various IT software developments. However, lately the parent companies had started reducing the cash flow with tighter control of Indian operations, resulting in the captive centres being acquired. Besides, as the global economic recession deepens further, companies, in order to sustain for longer time, have been following this policy."

Though the total value of such acquisitions is not known, the size of each centre averages about 100 employees. This way, top Indian firms gain access to the foreign markets of multinationals along with technological capabilities. After acquisition, erstwhile subsidiaries through Indian acquirers continue to serve the parent firm for three to five years to be extended on the basis of evaluation.

In the telecom space, acquisitions have been the preferred route for outward investment flows. The recent sale by Zain telecom of its African operations for $10.7 billion (excluding Morocco and Sudan) to Indian carrier Bharti Airtel is an example. Another example is the 2003 acquisition by Reliance Infocomm of Flag Telecom (USA) for USD 191 million.

3.3. Core skills in ICT R&D

The discussion in Chapter 1 showed that the services segment dominates the Indian ICT industry. The core competence of the services lay in managing the service process delivery and sustaining it in innovative ways. The Third European Community Innovation Survey (CIS3) highlights the following activities that contribute to innovation in services.

- ***Intramural research and experimental development (internal R&D)***: all creative work undertaken within the enterprise on a systematic basis in order to increase the stock of

knowledge, and the use of this stock of knowledge to devise new applications, such as new and improved products (goods/services) and processes (including software research).

- ***Acquisition of R&D (external R&D)***: activities as above, but performed by other companies (including other enterprises within the group) or other public or private research organisations.
- ***Acquisition of machinery and equipment***: any advanced machinery, computer hardware specifically purchased to implement new or significantly improved products (goods/services) and/or processes.
- ***Acquisition of other external knowledge***: purchase of rights to use patents and non-patented inventions, licences, know-how, trademarks, software and other types of knowledge from others for use in the enterprise's innovations.
- ***Training***: internal or external training of personnel directly aimed at the development and/or introduction of innovations.
- ***Market introduction of innovations***: including internal or external marketing activities directly aimed at the market introduction of the enterprise's new or significantly improved products. It may include preliminary market research, market tests and launch advertising, but it excludes the building of distribution networks to market innovations.
- ***Design, other preparations for production/deliveries***: procedures and technical preparations to realise the actual implementation of products and process innovations not covered elsewhere.

(OECD, 2007; p.18)

However, it is difficult to measure the above activities for the Indian ICT sector for two reasons. First, data are not available on the ICT sector related to the acquisition of R&D and other external knowledge. Second, activities like intramural research and experimental development (internal R&D); training; market introduction of innovations; and design, other preparations for production/deliveries are mostly internal operations of the firms and are not listed as a separate parameter in any statistical frameworks thus preventing quantitative analysis. Hence, the analysis is qualitative and based on a literature review of both academic studies and trade press materials.

Innovation in the Indian ICT sector can be discussed under the broad categories below:

3.3.1 Transition from onsite to off-shore

At present, the Indian ICT sector provides services in the domain of engineering services, R&D, and software products which are considered to be higher in the value chain in the industry. The present capabilities indicate the efficient transition of the sector from low-end service provider during the nascent stages.

The Indian software services export segment grew by sending Indian programmers to client locations, onsite, during the Y2K period which is called body shopping. In late 2000, Indian firms were executing the project in Indian locations, i.e., offshore (see Table 28). During the onsite period, the number of Indian programmers was significantly large with small teams at the Indian base which was reversed in the offshore period. During the onsite phase, Indian firms predominantly employed personnel with undergraduate degrees in engineering, since this was a requirement under US work immigration laws. This historical reason still explains the presence of around 70% undergraduate engineers employed in the industry. However, in the offshore period, control over the project was left to the Indian firms who people with undergraduate degrees in science to meet their programming needs.

Table 28: Composition of revenues by delivery location (in %)

Type	1995	1998–99	1999–00	2000–01	2001–02	2002–03	2003–04	2004–05
Onsite	66	54.4	57.4	56	45.2	43	36	29
Offshore	33	44.4	43.6	44	55	57.3	64	71

Source: Compilation by Bhatnagar (2006) from NASSCOM and others.

This transition from onsite to offshore shows the evolving project management capabilities of Indian firms. Indian firms were quick to adapt to universal quality certification requirements, like ISO series or Capability Maturity Model (CMM) levels for software service delivery. Global certification of Indian project delivery capabilities instilled confidence among the potential customers to outsource the projects.

3.3.2 Productised services

In initial stages Indian ICT firms attempted to develop software products, but they faced problems like distance from clients abroad; lack of financial strength for marketing and poor domestic market for experimenting. Most of the early firms, especially in the software domain, moved from developing products to concentrate on exporting software services which was less risky and gave better returns (Athreye, 2005).

Currently there are three types of players, who have different reasons for entering the product area. Large services firms like TCS and Infosys see products as a means to satisfy the twin objectives of improving margins and getting deeper into a client relationship. Services have by and large remained a labour arbitrage game, with revenues having a direct relationship with the number of people. Though Indian firms have improved their productivity and processes, products are IP-led and hence revenues are not a simple multiple of manpower cost. With margins under pressure due to rising wages and a stronger rupee, products are being looked at as an effective way of bettering margins.

The next tier and new players see products as their differentiation from the labour-intensive services game, which already has established big names. Companies like 3i Infotech and Ramco are examples of this category.

Then there are the vertical-focused players who see products as a natural extension of their services, or vice versa. This segment accounts for some of the best known names such as i-flex, Polaris, and Subex Azure. In the industry, this is called productised services. Although the clients are completely different in addition to variety of technological and industrial domains, Indian firms are able to standardise their services to the extent that service delivery to one client can be replicated for another client in the same domain. They are called productised services because they are not fully developed products, but can be customised within a short span of time. For instance, service delivered in terms of developing a set of banking system modules for a client in the US is replicated to similar clients in other parts of the US. Experiences in the service delivery provided adequate domain expertise to the Indian firms which were converted into productised services.

In fact, most of the products meant for the global market are vertical applications, which is a natural extension for a services destination like India. Core banking ranks first among areas where Indian products have been globally successful. In fact, in addition to well-known names like Flexcube, Finacle, and IntellecT, products from smaller companies like Infrasoft and CashTech have made their presence felt.

Of late, even telecom is seeing a slew of Indian products, led by companies like Aricent, Tech Mahindra and SubexAzure. It is no surprise that BFSI and telecom also happen to be two of the top three verticals for Indian services firms[17] (Dataquest, 2007).

3.3.3. Human capital capacity building

As the Indian ICT sector predominantly generates revenue in the human resources augmentation mode, revenue increases as more people are deployed in the projects; hence, there is a strong need to harness the manpower. Recently, NASSCOM pointed that less than 8% of graduates are employable in the ICT sector indicating huge quality differences.

Most large ICT firms have in-house training facilities. As most of the engineers are recruited from non-computer science backgrounds, they are provided fundamental training on all aspects of IT. In-house training ranges from two weeks to three months. The nature of training in terms of domain, period and depth depends on the nature of the project expected by the firms from the market; large firms may deploy a large number of programmers in any technological domain on short notice. Apart from in-house training, private training houses are used for unexpected demands. The Indian IT education market (the private sector only consists of IT training and e-learning exports) has grown by 13% to reach Rs 3,827 crore in 2008–2009, up from Rs 3,393 crore in the 2007–2008[18] (Dataquest, 2009).

Almost all the top firms collaborate with college-level engineering institutions to introduce industry-relevant curriculum or to train faculty. For example, Infosys's Campus Connect programme is an industry-academia collaboration to align engineering student competencies with industry needs. This programme was launched by Infosys in May 2004 with 60 colleges and has since grown global and is currently working with 397 engineering colleges in the country. As part of Campus Connect, Infosys conducts seminars and workshops in colleges to provide an industry perspective, share courseware case studies and information on industry projects, and invite college faculty to pursue research in mutual areas of interest, among other activities (Infosys company website).

Tata Consultancy Services has an Academic Interface Programme, which is a holistic initiative to enhance the quality of the emerging workforce across the globe by supporting students, faculty, institutes and the government. The programme engaged with 499 academic institutes in India and 85 institutes overseas during FY2009, conducting over 130 faculty development programmes that benefitted over 4,000 instructors and 400 workshops for over 52,000 students globally. Over 1,300 students benefitted from TCS internships and awards (TCS company website).

Mission10X is a Quantum Innovation project partnering with academia from across the country established by Wipro in 2007. This project aims to introduce a new learning model that would enhance the learning of students in the subject while developing key employability skills. This project is the outcome of intense research by Wipro across the academic community, student community, and the industry. Wipro plans to train over 10,000 of the faculty over the next three years, covering all the 1,300+ engineering colleges in the country. This will be done in a phased manner where in Year 1, 1,000 faculty members would be

[17] Dataquest, 2007. http://dqindia.ciol.com/content/DQTop20_07/ITGaints07/2007/107080318.asp (accessed 9 May 2010).

[18] Dataquest, 2009. http://dqindia.ciol.com/content/dqtop20_09/IndustryAnalyses/2009/109081335.asp (accessed May 9, 2010).

trained and in Year 2, 3,000; in Year 3 another 6,000 would be trained. This would be a one-week training programme where faculty would be certified on the Wipro Learning Model, which provides innovative teaching techniques. Wipro has created a strong team across the country to reach out to academia and conduct these sessions on campuses. The Mission 10X portal enables collaboration across faculty in the country to leverage best practices in teaching and learning. As part of Mission 10X, Wipro released the first faculty guide complying with the Wipro Learning Model. This was launched by the Vice Chancellors of four universities[19] (Dataquest, 2008).

[19] Dataquest, 2008, http://dqindia.ciol.com/content/top_stories/2008/408050701.asp (accessed on 9 May 2010).

4. THE INDIAN INNOVATION SYSTEM

4.1. Indian innovation and milestones in the past 20 years

Until the 1990s, the Indian economy was under state control and there was little incentive for private industry to invest in R&D. The science and technology system in the country was mostly driven by state-run research institutes and research laboratories without any pressure to compete at international levels. Sea-changes happened after the economy was liberalised in the 1900s. Domestic players faced global competition from MNCs on their home turf and the need to invest in R&D was tremendous. State-run research institutes and laboratories were asked to generate their share of revenues through commercialisation and to showcase their capabilities through patents (Pattnaik, 2005; Suman, 2006).

The Indian innovation system appears to be impressive with a broad-based network of government-supported research and development laboratories with multi-disciplinary expertise, a large education capacity with world-class engineering/teaching institutes, a dynamic private sector with a significant number of MNCs and R&D units, efforts to nurture technology entrepreneurship by the government and increasing foreign investment in R&D. However, there are problems with the extant system. Within these apparent strengths are embedded a number of limitations such as lack of dynamism in the government R&D system, poor research output from the higher education system, the absence of a vibrant high-technology sector, limited scope and impact of government support programmes for R&D, a science-technology divide, and inadequate spillovers of foreign direct investment in R&D (Krishnan, 2007).

One of the main factors responsible for the rise of the ICT industry in India was the development of IT clusters. ICT clusters are located in Bangalore, Hyderabad, Chennai, Pune, Mumbai and the National Capital Region (New Delhi, Gurgaon, and Noida). An estimate from the United Nations Industrial Development Organization says that the "total number of clusters in the country could be over 2400, including about 2000 rural/artisanal clusters" (Das, 2005, p.12). Examples include Panipat (blankets); Tirupur (cotton hosiery); Agra (shoes), and Ludhiana (woollen knitwear).

Some broad factors that have been driving the success of IT clusters in India are:[20] 1) well-educated human resources; 2) use of English in higher education; 3) favourable government policies towards the IT sector; 4) competition among small and medium sized-companies. 5) large potential growth of GDP, increasing demand in the domestic market. Table 29 shows the milestones in the evolution of innovation systems in India:

[20] IT in India - Tech Cluster Analysis (http://www1.american.edu/academic.depts/ksb/citge/India%202.htm) Accessed 2 May 2010.

Table 29: Evolution of innovation systems in India

Year	Policy Initiative
1958	Scientific policy resolution – to foster, promote and sustain, by all appropriate means, the cultivation of science and scientific research in all its aspects—pure, applied and educational.
1970	Indian Patents Act – no product patents for food, pharmaceuticals, and chemical sectors.
1983	Technology Policy statement of 1983 – to develop indigenous technology and ensure efficient absorption and adaptation of imported technology appropriate to national priorities and availability of resources. Establishment of Technology Information Forecasting and Assessment Council (TIFAC) – to forecast technology and conduct techno market surveys which are used for policy making.
1985	R&D Cess Act – to collect levy on technology imports.
1988	Venture capital guidelines announced.
1991	The new Industrial Policy (NIP), July 1991 emphasises "self-reliance and development of domestic technology through investment in R&D."
1995	Technology Development Board Act – to promote development and commercialisation of indigenous technology and adaptation of imported technology for wider application.*
1996	CSIR 2001: vision and strategy – to make the CSIR a model organisation for scientific industrial research and a path-setter in the shifting paradigm of self-financing R&D; a global R&D platform providing competitive R&D and high-quality science-based technical services the world over; and a vital source of S&T for national societal missions which combine technology with a human face.✓
	Securities and Exchange Board of India Act. – to provide for the establishment of a Board to protect the interests of investors in securities and to promote the development of, and to regulate, the securities market and for matters connected therewith or incidental thereto.ε
	Venture Capital Funds Regulations, 1996 – to regulate and promote the activities of domestic venture capital funds.
1997	Ninth Five-Year Plan on science &technology introduced.
1999	Indian Patents Act 1970 amended as per the needs of TRIPS, Uruguay Round which permitted patents in the pharmaceuticals, food and chemical sectors.
2000	New millennium Indian technology leadership announced.
2003	The science and technology policy of 2003 – emphasis and commitment on R&D by the government. It seeks to achieve synergy between industry and scientific research and envisions the creation of "Technology Transfer Organisations" as associate organisations of universities and national laboratories to facilitate the transfer of technologies generated. To promote international science and technology co-operation in order to achieve the goals of national development and security, establish an IPR regime which maximises the incentives for the generation and protect intellectual property by all types of inventors.£

Source: Mani and Kumar (2001).

*- http://www.tdb.gov.in/

✓ - http://www.csir.res.in/External/Heads/aboutcsir/CSIR%20vision%202001.htm

ε - http://www.sebi.gov.in/acts/act15ac.html

£ - Suman (2006).

Although India's success in the IT sector has been phenomenal and its software development is widely attributed to its human capital, it is not clear whether the growth has led to industry-wide innovation. Parthasarathi and Joseph (2001) argue that the innovative behaviour of firms under export orientation has been one wherein firms have depended heavily on collaboration with their foreign counterparts. Foreign firms, which possess the property rights for new technologies, usually assign specific tasks to Indian firms that do not require any serious research and development (R&D) efforts. Thus, R&D intensity in the industry has been negligible and has not recorded any marked increase. Most of India's IT industry appears to have followed the path of export services rather than develop its own brand products. In fact, from the R&D point of view, the nature of the IT industry was found to be "applied", "service-oriented", or "incremental" in its innovation (Tschang et al., 2003). A bigger R&D thrust will be necessary for Indian software enterprises to upgrade their export profile to higher value-adding services and products, and to establish themselves as innovators and developers of new products and technologies rather than as mere providers of coding and programming services (Kumar, 2001). Experts also believe that in terms of implementing R&D projects between the IT sector and other areas like space technology, while co-ordination takes place on a need basis, organisations involved in projects as well as policy continue to function largely as islands with very little networking (Chandrashekar and Basvarajappa, 2001).

However, the internationalisation of R&D has resulted in multinational companies becoming eager to build on India's initial advantage in software development and engage in both technology deepening and technology widening activities. Development centres of MNCs in India make significant contributions to the vision and strategy of their parent corporations by world-class delivery, processes and high-quality engineering and services talent. The increased number of international companies and continuous growth of engineering human resource is a clear indication of the country's high-quality skill capabilities. Microsoft, IBM, Oracle, AMD, NetApp, Adobe, Intel, EMC, and Quantum have R&D centers in India and a significant portion of their product development is carried out from here.

Despite this, India's ICT R&D expenditure as a percentage of GDP remains one of the lowest in the world at 0.8% of GDP. The Working Group on Information Technology sector under the Eleventh Five-Year Plan observed that national investments in R&D should grow with GDP or alternatively at the size of the output of the sectors concerned, in this case IT and electronics or ICT and electronics. Second, the base of 0.8% must progressively increase to around 1.6% by the end of the Eleventh Plan period, i.e., 2012 and 2.4% by the end of the Twelfth Plan period, i.e., 2017 in line with India's aspirations to emerge as a knowledge economy and strengthen national competitiveness.

The sources for R&D funding and delivery in the ICT sector in India are:[21]

1. R&D undertaken by academia and R&D labs through extra-mural funding and funding by Dept. of Information Technology (DIT), Dept. of Science & Technology (DST), Min. of Human Resources Development (MHRD) and from funding by industry.
2. First-party labs which undertake R&D largely for their own missions or to fulfil in-house needs as in the case of space, atomic energy, Defence Research & Development organization (DRDO) and user agencies/sectors.
3. R&D undertaken by third-party R&D labs, as in the case of Center for Development of Advanced Computing (C-DAC), Center for Department of telematics (C-DOT),

[21] The Working Group on Information Technology sector under the Eleventh Five-Year Plan 2008-2012 (p.122).

Council for Scientific and Industrial Research (CSIR) Labs, etc. that get funding from the respective ministries and various sources.

4. R&D work undertaken by the Indian public sector as in the case of Bharat Electronics Ltd. (BEL), Electronics Corporation of India Ltd. (ECIL) and Indian telephone Industries (ITI).
5. R&D undertaken by the large private Sector and SME sector (for domestic markets and exports) including export of R&D services.
6. R&D undertaken by global MNCs and other foreign companies

One of the major shortcomings of the Indian ICT sector repeatedly discussed by the existing studies is the lack of research and development (R&D) activities performed by the firms. There is no reliable data available on the nature of R&D investment or the number of research personnel in the Indian ICT industry.

Table 30: Industrial R&D expenditure by leading industry groups in 2005–06

S. No.	Industry Group	Public Sector			Private Sector			Industrial Sector		
		R&D			R&D			R&D		
		Units	(Rs. million)	%of total	Units	(Rs. million)	%of total	Units	(Rs. million)	%of total
1	Drugs & Pharmaceuticals	5	20.2	0.15	156	28268.6	45.10	161	28288.9	37.36
2	Transportation	4	689.5	5.29	60	10472	16.71	64	11161.5	14.74
3	Defence Industries	9	5060.1	38.80	7	156.7	0.25	16	5216.8	6.89
4	Electricals & Electronics	12	543.8	4.17	132	3754	5.99	144	4297.8	5.68
5	Chemicals (other than fertilisers)	15	282.1	2.16	161	3008.7	4.80	176	3290.7	4.35
6	Fuels	14	3161	24.24	9	108.5	0.17	23	3269.5	4.32
7	**Information Technology**	**1**	**118.1**	**0.91**	**20**	**3066.3**	**4.89**	**21**	**3184.4**	**4.21**
8	Bio-technology	1	12	0.09	70	2777.4	4.43	71	2789.4	3.68
9	Metallurgical Industries	11	890.2	6.83	50	1428.7	2.28	61	2318.9	3.06
10	Industrial Machinery	2	998.8	7.66	29	397	0.63	31	1395.8	1.84
11	**Telecommunications**	**2**	**396.3**	**3.04**	**30**	**986.7**	**1.57**	**32**	**1383**	**1.83**
12	Soaps, cosmetics and toilet preparations	1	1.4	0.01	10	1372.2	2.19	11	1373.6	1.81
13	Miscellaneous mechanical engineering industries	0	0	0.00	55	1373.1	2.19	55	1373.1	1.81
14	Others	35	869.1	6.66	319	5514.2	8.80	354	6383.3	8.43
	Total	**112**	13042.6	100	**1108**	62684.1	100	**1220**	75726.7	100

Source: Research and Development Statistics 2007– 08, Ministry of Science and Technology, New Delhi.

The contribution of the private sector to ICT R&D (other than R&D outsourcing) has been a small proportion of the country's R&D expenditure. In about five years there should be a goal of bringing it up to a level of 50%. Even Taiwan went through such a cycle where government contribution to R&D progressively came down from 80% to a minority share.

In India too, the private sector contribution to R&D has progressively increased, thus increasing its contribution to the overall percentage of national R&D spending. However, government R&D spending needs to be significantly increased, so that the target of 50% represents a larger pie of national total R&D spending.

The current report uses a wide range of published information, but goes beyond an understanding based on official indicators recorded by government agencies (R&D spending, number of engineers and scientists, patents and publication indices, foreign investment, trade

and other statistics), as this data is incomplete and can be misleading, in order to understand the status and potential of India in ICT R&D and its internationalisation.

4.2. Service process innovation: the budget telecom model

In India, like in many other countries of the region, telecom connectivity was achieved for the majority of the people, including substantial numbers of the poor, because the Indian government removed or lowered barriers to participation in the supply of telecom services and created conditions somewhat conducive to competition, even if less than perfect (see Table 8 for policy and regulatory measures facilitating this). This was the necessary condition.

Where multiple suppliers existed, intense competition, the critical step in implementing the budget telecom network model, occurred. The radically lower prices attracted more minutes of use, which in turn made further reductions possible. Operators were able to load their networks with high volumes of revenue-yielding minutes because they had succeeded in reducing the transaction costs of dealing with low-volume customers. Prepaid, which accommodates the needs of those with irregular earning patterns, was also a critical element. Along with these business process innovations, the exponents of the budget telecom network model also succeeded in drastically reducing costs, especially operating expenditure (opex). The new model makes ARPU (Average Revenue per User) irrelevant because what really matters is how many revenue-yielding minutes are carried on the network and not how much money is earned from a customer.

The difficult policy and regulatory environment and the low purchasing power of customers in the region appear to have compelled the operators to innovate, both in terms of squeezing operating expenditures and in terms of serving the 'long tail'[22] of customers who use only a few minutes of calls a month. The latter innovation rests squarely on the reduction of transaction costs associated with supporting pre-paid customers.

The extension of the budget telecom network model to broadband requires that small, pre-paid, irregular payments be allowed, which is a significant deviation from the dominant always-on, all-you-can-eat models. It appears that the former is already emerging in the mobile-based broadband offerings such as high speed packet access (HSPA).

The low prices and high use of the telecom network in India point to the core explanation for the success of connecting millions in the past decade. It is the discovery and application of an entirely new business model in South Asia, the 'budget telecom network model', which is akin to the budget airline model implemented by the likes of Air Asia and Ryan Air.[23] The budget telecom network business model is an innovation, driven by intense competition and in response to the hard regulatory environments and low purchasing power of countries like India. If not for competition, the innovation would not have happened. However, the model increases the volatility of earnings and results in lower quality of service (Samarajiva, 2009)
Telecom manufacturing is another facet of the sector that has emerged as a hot topic in industry circles. India is fast emerging as a hub for global telecom manufacturing and the production and exports of telecom equipment in the country have been steadily rising.

[22] Anderson, C. (2006). *The Long Tail: Why the future of business is selling less of more*. New York: Hyperion Books. Whereas Anderson focuses on the long tail of products such as low-demand books, the budget telecom network model is based on the long tail of low-volume customers.

[23] Nokia (2008a). Affordability key in bringing digital inclusion. *Expanding Horizons,* 1, 12-13; Nokia (2008b). A roadmap to affordable mobility in emerging markets. *Expanding Horizons,* 4, 4-7.

Leading global players have made significant investments in setting up manufacturing and R&D facilities in India, with many more being planned.

On the other hand as documented in Appendix A and B, FDI flows into India have been quite encouraging but domestic companies like Tata Teleservices and Reliance Infocomm have driven the majority of the investment. Outflows of FDI have also gained importance with companies like Bharti Airtel acquiring firms like Zain telecom.

4.2.1. Market-driven innovations in Indian telecommunications

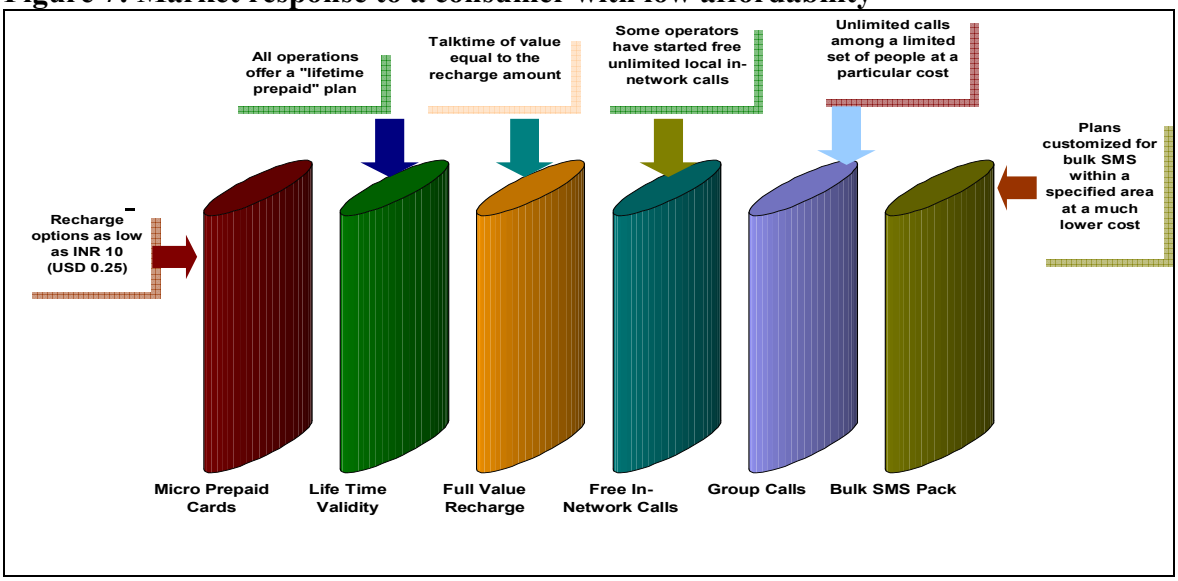
Once competition was established, which was a necessary condition for the growth of the sector, the market took over. New entrants eager to expand their market shares by increasing their pie and not just by eating each other's market shares offered alternatives to standard services. In the monopoly era different consumers were deterred from having a telephone due to different factors– high installation charges, high rentals, fear of building up large bills, and the fear of incurring debt. Consequently, after liberalisation the compulsions of the market made service providers realise that options needed to be offered to consumers that are differentiated by service quality and price, enabling consumers to select the option most suited to their needs. Such options should incorporate:

1. Low installation charges.
2. Low rentals.
3. Allow the consumer to control expenses.
4. Permit the consumer to make small, frequent and regular payments.

The issue of allowing the market to function without any impediment assumes relevance in this context too. The market is the only known institution that can coax the necessary innovation (by offering prompt rewards for innovation, by imposing the pressure of competition, or by punishing failures to respond to the market) from market players (the networks) to bring into operation technologies and tariff packages that would incorporate the above features.

One form of technology that encompasses these features is pre-paid cellular service. Involving low installation charges and low rentals, it is ideal for low-income consumers who are unwilling or unable to commit to fixed monthly charges, lack the creditworthiness for normal service, and want greater control over call spending. The latest figures for the GSM industry show that 86% of the mobile subscribers in India are in the pre-paid segment. Some of the innovations and their impact on mobile subscription are summarised in the two figures below.

Figure 7: Market response to a consumer with low affordability



One major barrier to ownership was the cost of a handset. Reliance Infocomm, for the first time in India, offered free handsets along with the service. This offer was managed in three ways. First, the pioneer offer had a built-in contract of three years for every customer; this guaranteed cash flows and minimised churn, allowing them to discount the cost of the phone. Second, the company entered into exclusive agreements with handset vendors like LG and Samsung; for a guaranteed purchase of huge volumes (between 1 million and 8 million phones), the prices were negotiated to rock bottom. Third, the company limited the choice of handsets to two models per brand, thus ensuring mass production and further reduction in prices. Internal estimates say that the handset model which cost Rs.10, 500 (USD 233) on the open market was procured by Reliance Infocomm for Rs.800 (USD 17.8).[24]

Another important innovation that allowed a low-income consumer to own a telephone was virtually zero rental for service in the form of lifetime validity offers. Then came the micro pre-paid where a low income consumer could buy talk-time for denominations as low as Rs. 10 (USD 0.25). Hutch (now known as Vodafone) aligned the products to the rural market. One of their innovations is the popular *chota* recharge, or micro recharge. When the industry required Rs.200 (USD 5) as the minimum recharge, Vodafone went down to Rs.10. This offer was a shift from the earlier urban-centric monthly income cycle payment plan and was tailor-made to the needs of a daily wager. Under Bharti's Super Lifetime Pre-paid plan, customers can stay mobile by paying just Rs 999 (USD 25). They need to use a minimum of Rs 200 every 180 days to retain lifetime validity.

Recognising that there can be demand-side constraints like the level of awareness and education to understand the usefulness of mobile telephony, Nokia is reaching the hinterland with its Nokia vans. The van forms a travelling retail and distribution centre designed to improve awareness of the benefits of mobility. Potential users get to know the full range of products, including entry-level mobile phones and related services. In Nokia's three India R&D labs it is working on 'shared' phones. For reasons of affordability, in rural areas a phone may be shared by several people. The models being launched to cater to this need will have separate address books and individual billings. To enhance the usefulness of mobile phones to illiterate customers, the company has designed software that cues users with icons in addition

[24] These findings are attributed to Sangeeth Varghese. For details see Varghese, S. (2006).

to words. The biggest question remains one of price. Nokia's entry phones are about USD 45; Vodafone offers models that are closer to USD 25; and in a move that generated headlines around the world, the Indian manufacturer Spice Limited recently announced plans to sell a USD 20 'people's phone'.

According to Nokia's[25] understanding of a low-income market like India, vendors too have a role to play. Indian operators currently operate at a very low average revenue per user per month (ARPU) of USD 6, but they still make a profit as revealed by their EBITDA. Estimates have been made that the telecom business in India is viable at a low ARPU of USD 4, without a handset subsidy. Solutions that telecom vendors can provide are critical to operators' ability to meet these minimum revenue requirements and thus they should take the onus of providing affordable solutions to exploit the synergies. New types of infrastructure solutions that significantly decrease capital and operational expenditures for operators are imperative in order to reach an affordable total cost of ownership (TCO) for rural subscribers. Shelter-less base stations, auto-provisioning of subscribers, over-the-air SIM card charging and the incorporation of adaptive multi-rate (AMR) codec are some of the more modern technologies and approaches vendors are employing in low-ARPU environments such as India. On the other hand, some observers argue that a low ARPU model of affordability is sustainable due to operators cutting investments (to reduce their costs) on improving the quality of service. Hence, the full exploitation of the network as expressed in high Minutes of Usage (MoU) for India at 471 minutes per user, points to the fact that the operators are working at full capacity and at the minimum efficient scale of their investment.

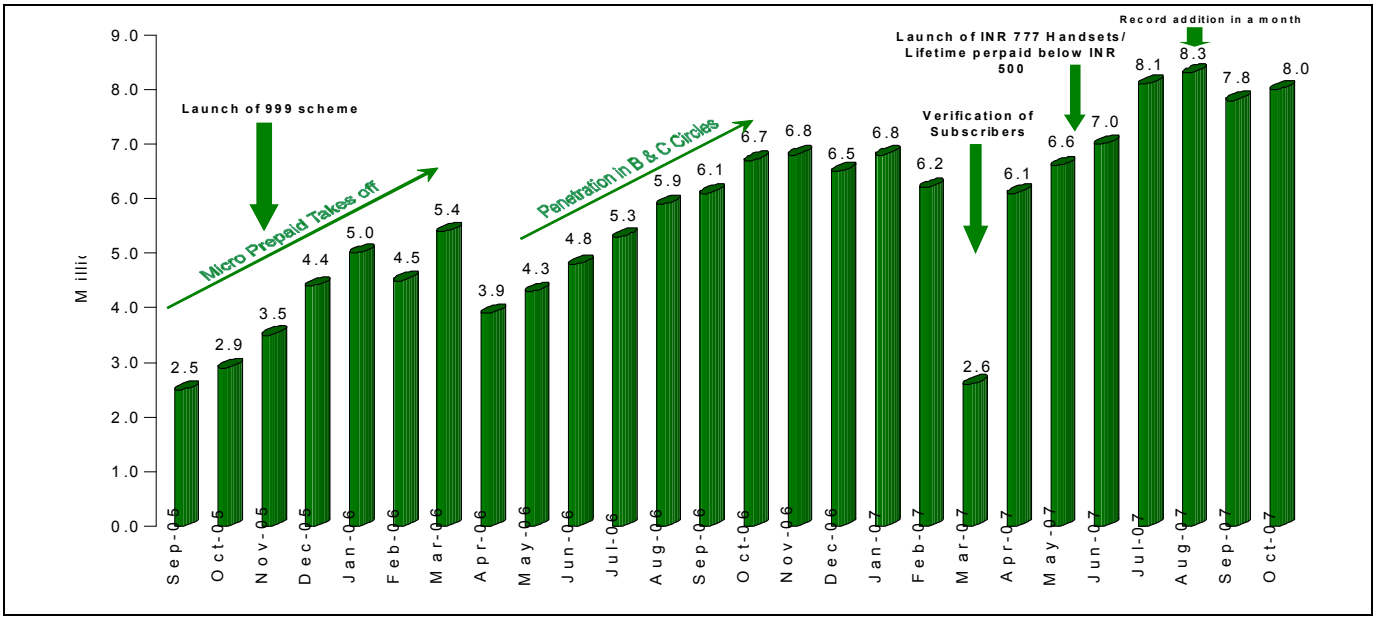
For instance, Texas Instruments has designed a single-chip solution that can be used for GSM and GPRS mobile handsets, instead of the triple-chip installation. This new invention could cut handset production costs by up to 30%. The single-chip solution opens up possibilities for production of handsets priced less than Rs. 1,000 (~20 USD), a price that is regarded as trend-breaking and an entry ticket to the market for the less privileged in India. GSMA's Emerging Market Handset (EMH) programme, which is part of the "Connecting the unconnected" initiative, has led to a partnership of the 10 mobile telephony operators with Motorola for about six million of Motorola's two low-cost handsets, priced at USD 30.

In 2004, Bharti Airtel, India's largest mobile operator, struck deals with Ericsson and IBM for network and IT outsourcing. The network outsourcing agreement with Ericsson linked revenue growth with network expansion which enabled both Bharti Airtel and Ericsson to benefit from each others' strengths. The IBM deal was based on a set of performance requirements which benefited Bharti Airtel by leveraging IBM's IT expertise. Bharti Airtel focused on coverage and expansion planning, marketing and distribution, designing innovative schemes to stimulate subscriber and usage growth, network planning, building, commissioning, billing, subscriber management and other IT operations that were not part of their core strengths. Other operators have followed suit, but this has yet to turn into a global trend.

Indian operators have consistently refrained from subsidising handsets costs directly but have provided free minutes of usage to subscribers to make the burden of buying handsets easier. Last but not the least, second-hand phones also play a role in increasing affordability. Second-hand phones cost as little as Rs. 300–400 (USD 10).

[25] Nokia (2006), New Horizons, Quarterly Newsletter, Issue 1, 2006.

Figure 8: Lifetime validity, micro pre-paid and network expansion: impact on mobile subscription



Source: BDA Report, December 2007.

India's telecom business model is based on low-cost, high-volume traffic and innovative packaging of services. Telecom operators have used the demographic advantage of India (a large and youthful population) to exploit economies of scale, by increasing volumes, reducing costs and thus having one of the highest earnings margins in the world. Moreover, value added services driven by cricket, game shows, and the Hindi film industry are a major source of revenue (around 10%) for the operators, permitting them to have low margins on their voice business. This is despite the fact that the Indian telecom sector has one the highest levies and duties imposed on it. The total regulatory charges are 17~26% of revenue, exclusive of goods and service tax. This high incidence of levies and duties means a low return on capital, thus adversely impacting the availability of funds for network expansion.

The most important lesson that we draw from the analysis is also the most trite: low prices increase usage by existing customers and attract new customers; the resulting higher utilisation of the network enables operators to cover opex and capex and generate profits that make it possible to further grow the networks and the services provided over it at low price levels: these price levels allow the maintenance of high network utilisation and continuation of the virtuous cycle.

4.2.2. Research and Development in Telecom Manufacturing[26]

In order to build capacity to strengthen the capability for telecom technology enhancement, the Government of India initiated the concept of Telecom Centres of Excellence (TCoE), established in a Public-Private Partnership (PPP) mode involving India's major telecom companies and leading educational and research institutions in the country. Apart from application-oriented research, the centres are designed to assist and offer training to corporate managers to manage networks and services as well as decision-makers of telecommunication entities to manage sector reforms.

[26] This section (4.2) is adapted from KPMG, DoT and FICCI, 2009, *The Indian Telecom Success Story*, Indian Telecom 2009, New Delhi, India.

Seven TCoEs have been established in the country at leading academic and research institutions with the support of seven major telecom operators. Each centre has a focus area of excellence; thus, the seven centres cover all aspects of telecom from technology to disaster management of telecom infrastructure to customer care and business model innovation. This year, the TCoEs undertook around 78 R&D projects that included energy-efficient devices for rural applications, use of non-conventional sources of energy, energy-efficient power conversion, applications related to promoting broadband wireless access, applications related to rural educational and rural livelihood, value-added services such as mobile-based video conferencing, development work on next generation networks, etc. In addition, the TCoE at IIT Chennai has been accepted by ITU-R as an evaluator for the International Mobile Telecommunications-Advance (IMT-A) proposal for 4G networks.

4.2.3. Contract R&D: laying the foundations

A significant proportion of the R&D revenue coming India's way in the technology arena in the past few years has been in the form of contract research. The Economist Intelligence Unit (EIU) has defined India as an R&D hotspot: a place where companies can tap into existing networks of scientific and technical expertise; which has good links to academic research facilities and provides an environment where innovation is supported and easy to commercialise.[27]

The EIU further notes, "India became a software hub in the 1990s. As a large Asian country where English is spoken, wages are modest and Western education is available, India has quickly grown as an R&D powerhouse." The cost advantage of having a large pool of inexpensive, English-speaking workers is a large part of India's attractiveness. The possible cost savings figures have made the business case quite evident. The availability of good quality talent is bolstered by the presence of good quality higher educational technological institutes and a large network of government research labs.

The best results for outsourced R&D have been most evident in the technology sector. India's leading technology companies are beginning to build sustainable contract R&D businesses.

Within the technology sector, semiconductor design or design of chips is an area where multinationals came to India a long time ago and it remains a growth area for R&D outsourcing. India has about 100 VLSI companies, with more than 5,000 engineers providing semiconductor design services.[28] Many large semiconductor companies, including Texas Instruments, National Semiconductors, Intel, Analog Devices, ST Microelectronics, Cadence, and Motorola have established research facilities in India.

Indian IT companies also have large numbers of engineers working in the areas of VLSI design and embedded systems. While VLSI involves the design of chips, the scope of embedded systems is much broader, involving chip design, software, signal processing and operating systems, and is expected to be a significant opportunity for contract R&D providers (FICCI, 2007).

[27] Contract Research for Global Firms Creates Hotspots for IT, Telecom and Biotech, Knowledge@Wharton.
[28] VLSI Society of India.

Table 31: Telecom centres of excellence (TCoE)

S. No.	Associate Institute	Sponsor	Work Assigned
1	IIT Kharagpur	Vodafone Essar and Texas Instruments	Next Generation Network (NGN) & network technology
2	IIT Delhi	Bharti Airtel	Telecom technology & management
3	IISC (Indian Institute of Science), Bangalore	Aircel & Texas Instruments	Information security and disaster management of infrastructure
4	IIT Kanpur	BSNL and Alphion	Technology integration, multimedia and computational mathematics
5	IIT Chennai	Reliance Communications	Telecom infrastructure and energy
6	IIT Mumbai	Tata Teleservices	Rural applications
7	IIM Ahmedabad	Idea Cellular	Policy, regulation, governance, customer care and marketing

Source: Department of Telecommunications, Government of India.

4.2.4. Designed for India

India's telecommunications infrastructure continues to develop rapidly, trying to meet local needs and overcome a wide variety of challenging regional characteristics, local customer requirements and conditions. This helps vendors understand the growing needs of the global market with regard to issues such as scalability, density and environmental ruggedness.

The unparalleled growth of the Indian market, innovative telecom business models, and challenging environmental conditions make it ideal for innovation and a focus area for global telecom OEM R&D. The knowledge that can be gained in the Indian market is invaluable, and gives companies a significant edge, improving their product offerings for Indian and global customers.

Telecom vendors doing significant business in India are designing products to address this demand, allowing increased scalability and the addition of new functionalities on existing platforms without the need to replace existing legacy equipment. For example, products developed with the Indian market in mind are capable of expanding their capacity four-fold simply by swapping the platform's line cards.

India's climate is notable for its extreme temperatures and humid summers. This, coupled with its harsh environmental conditions and high levels of air pollution, requires additional qualification procedures for telecom equipment, in addition to those specified in existing international standards. In response to these conditions and the resulting local and international standards, vendors have begun applying anti-sulphur coating to cards deployed in India to protect them from chemicals in the country's ambient polluted air. In addition, the chip packaging for critical components is upgraded to industrial-grade to sustain a wider range of temperature levels ranging from –5 C to 80 C degrees.

The adjustments required by the challenging conditions in India have also contributed to improved reliability elsewhere; the flexibility and scalability they bring will help increase a vendor's success around the globe, offering operators the same benefits of scale and adaptability dictated by the India market.

India is without question one of the most compelling emerging telecom markets in the world. Due to its low-cost, high-quality networks and innovative marketing, the country is a model of efficiency in global telecom. Vendors working in India believe that their presence here and their relationship with Indian companies will eventually benefit all their customers globally. Multinationals are increasingly taking notice of India beyond just its talent pool and viewing it as a key development ground for their R&D efforts.

Efforts are being continuously made to develop affordable technology for the masses, as also comprehensive security infrastructure for telecom networks. Research is on for the preparation of tested infrastructure to enable interoperability in Next Generation Network. Modern technology inductions are being promoted. Pilot projects on the existing and emerging technologies have been undertaken including WiMax, 3G, etc.

In light of the above discussion, it is clear that the forces of competition and private investment can cover a lot of ground. Recognising the good performance in terms of increased connectivity, low prices and greater choice yielded by the new business model, it is in the interests of governments and regulators to facilitate its successful implementation through good policy and regulation. Good ex-ante policies in areas such as market entry, mergers and acquisitions, and taxation (including universal-service levies) have to be further tuned to allow the market to percolate its benefits to the bottom of the pyramid (BOP). In this context ex-post anti-trust regulation assumes a larger importance given that freer markets have the solution to bridge the gaps.

5. OUTLOOK FOR THE FUTURE AND THE CONCLUSIONS

5.1. Main conclusions of the key trends

India is the world's fourth largest economy as far as purchasing power parity is concerned, and its growth rate has been impressive for the past two decades (9.1% in FY 2007–2008). It is well placed to meet global market demand, with 64% of the population in the working age group (15–60 years). Agriculture's contribution to the national economy is declining slowly, with a rise in the services and manufacturing sectors.

The Indian ICT industry contributes to the national economy in many ways and almost all states in India are targeting the ICT sector as a vehicle for economic development. This sector employs about 2 million people directly, with indirect employment projected at four times direct employment. Broadly speaking, the Indian ICT sector has evolved over three phases: up to 1984, from 1984 to 1990, and post 1990. In the first phase, apart from trying to establish its own technological trajectories, the state attempted to run the industry which resulted in no commercial sector. In this phase, there was no great differentiation between software and hardware. In the second phase, the government realised that software was a viable option for income generation and technological capability enhancement. In the third phase, the software export industry blossomed, aggressively promoted by both national and state governments. Consequently, the export-driven growth model ignored the hardware and domestic sectors, despite their huge potential. Though the sector is growing in all domains, it is predominantly a service-driven software sector.

Up until the 1990s, the Indian economy was under state control and there was little incentive for private industry to invest in R&D. The science and technology system in the country was mostly driven by the state-run research institutes and research laboratories without any pressure to compete at international standards. Sea changes happened after the liberalisation of the economy in the 1900s. Domestic players faced global competition on their home turf from MNCs and the need to invest in R&D was tremendous. State-run research institutes and laboratories were asked to generate their share of revenues through commercialisation and showcase their capabilities through patents.

Information on the Indian ICT industry is abundant, but access to firm-level data is difficult. The industry is dominated by larger players, with the top 200 firms contributing 86% of the total revenues. In the rest of the world, small high-technology firms adapt to market conditions and spur overall sectoral innovation. In India, however, small firms are more like hygiene factors whose absence rather than presence is felt. Small firms serve as training grounds for entry-level programmers before they migrate to larger firms. The role played by small firms in the innovation ecosystem in Silicon Valley is well proven, but in India the linkages between small and large firms are weak. The presence of small firms in technological collaboration, in terms of cross-licensing or trading of IP blocks, is minimal.

Some positive inferences can be made about the amount of FDI made by foreign firms. Foreign direct investment (FDI) followed three successive stages in India. The first set of firms came to India to exploit the local market in India. For instance, Suzuki (Japan) was the first major automaker to collaborate with the Indian government, and was followed by all the world's major players. The second stage saw the entry of large software houses into India,

either directly or through joint collaborations. The third stage is the establishment of R&D centres by new or already present players.

An analysis of secondary data showed that most multinational firms come to India to make use of low-cost high-skilled labour and continue working on activities delegated by their headquarters. Over time, the Indian centres gain confidence and start undertaking high-skilled work from the parent firms. Also, India offers a strategic location closer to emerging markets like the Middle East and East Asian countries.

A recent study reported that 594 R&D centres have entered India over the past six years. Some of them claim to perform real 'research' rather than 'development' work. All the MNCs follow the conventional outsourcing model: they enter India to set up cost centres, which then evolve into technology centres. This transition is not reflected in hard statistics: for example, fewer patents are filed by Indian firms than by the Indian centres of multinationals.

On the other hand, innovation in the hardware domain is skewed towards embedded software, especially in the telecom domain. Poor manufacturing capabilities, lack of adequate support infrastructure and competitive producers like China, Taiwan and Korea will continue to unsettle the Indian ICT industry.

University-industry alliances are much to be desired, but they are limited to campus placement and student internships. Job offers at the end of three years for undergraduate engineering students (in the pre-recession period) indicate that students disregard the curriculum taught in the fourth year. Universities are struggling to attract students for PhD programmes and face faculty shortages in ICT areas. Hence, Indian universities cannot be viewed as a hot-bed for innovative companies. The labour pool in terms of engineering or ICT-related education is large, but a closer look reveals a poor research component.

There is no direct data available on the regional revenue distribution of the industry. However, the presence of ICT firms in six main clusters, namely, Bangalore (Karnataka), Mumbai and Pune (Maharashtra), Chennai (Tamil Nadu), Hyderabad (Andhra Pradesh), and the National Capital Region (New Delhi, Noida, and Gurgaon) is prominent, and almost 93% of the export revenue came from these regions. Similar generalisations can be made for overall industry revenues. A comparison of the major ICT clusters shows that the Bangalore cluster presents the most mature ecosystem for the ICT industry. Due to its historical lead advantages, it has a deep labour market, proximity to reputed research institutes, government research labs, the presence of Venture Capital, and a healthy mix of large domestic firms, multinationals and supplementary firms.

Both state and central governments have been trying to expand the presence of the Indian ICT sector beyond the six established clusters. Though their efforts are impressive, the sustainability of the industry depends on soft infrastructure factors like the availability of a high-end labour pool, a competitive pool of suppliers, access to power centres of policy making, access to venture capital, and opportunities for interaction that enhance innovation, etc. Given the lack of soft infrastructure, it will be difficult to sustain the industrial growth in Tier II cities.

The presence of a domestic market of critical mass is crucial for the long-term growth of the firms and the industry. The small size and low income potential of the domestic sector force firms to depend exclusively on the export market, making this sector more vulnerable to

foreign market and policy fluctuations. Significant efforts are being made by the government to encourage IT penetration by encouraging computing in local languages, introducing computers in schools and nation-wide e-governance projects. Preliminary findings from independent studies show problems in implementation and forecast a long period to achieve the desired results.

A trade association report shows that the contribution of the Indian ICT sector to outward FDI, measured through values of mergers and acquisitions (M&A), is significant, with the total number of deals involving Indian ICT firms increasing by nearly 17%, i.e., USD 3.4 billion in 2008 from USD 2.9 billion in 2007. Acquisitions are typically made in the software development and semiconductor design areas, followed by associated business processing domains. There is also evidence of Indian firms acquiring the R&D centres of multinationals.

Though Indian firms are expanding their global reach and technology domains in service through acquisitions, it is difficult to conclude that R&D capabilities have been acquired. Indian firms continue to cater for western clients in terms of software product development or engineering services and innovate for in-house consumption, rather than developing off-the-shelf products for the open market.

Since the Indian ICT sector concentrates on services, innovation is predominantly on processes. This service innovation is observed in other areas:

- transition from onsite to off-shore – from execution of projects at the client's site by sending people to execute and manage projects in India;
- productised services – Indian firms standardise the services provided to clients and sell them as productised services, a level below off-the-shelf products;
- virtual extension – Indian firms serve as sub-contractors but interact with primary clients directly;
- and human capital capacity building – though human capital is available, skill gaps are met by the sector itself.

5.2. The years ahead: outlook for the future

The Indian ICT sector may lose the patronage of the government. Tax incentives provided under the Software Technology Parks of India scheme (1991) which provided much impetus to the growth of software service exports will be withdrawn in 2010. Though the government has introduced other policy initiatives, like special economic zones, the special status attached to services exports may be withdrawn slowly. This will have significant implications for the industry. The cost of operations will increase as firms will have to pay tax. With the rising cost of infrastructure and labour, the cost advantages will be eroded. New alternative destinations will compete with India on low-end segment domains. China is slowly making inroads into the service sector and making tremendous efforts to close the English language gap which is at present advantageous to India.

In order to beat international competition in the outsourcing market, India needs to do the following:

Service offerings in high-end technology domains, where the learning curve is steep and competition is less fierce, should be upgraded. The growing contribution of software product development and engineering services to the industry's overall revenue and development IP

blocks, especially in the embedded software segment, has already been recognised by many entrepreneurial firms in Bangalore that are making this transition.

Large service firms are exploring other developing countries to tap into the cheaper human capital and to be close to the prospects by setting up branches there. This move has yet to deliver the desired results, but is expected to be successful in the near future. Large firms are also exploring second-tier cities in India to control costs. Active involvement by the state governments will decide whether or not this movement is successful.

The domestic industry is gradually growing and is expected to grow faster as ICT expenditure by the other industrial sectors is increasing. There will be growing interest among domestic firms to exploit the domestic sector in addition to exports. There is the possibility of developing more software products that cater for the domestic market which, in turn, will be sold to similar global markets.

The Indian IPR regime is getting stronger with revised laws and regulations. As the country will offer a secure environment for innovations, there will be an increased move towards high-value activities in the innovation chain by multinationals, which will also collaborate more with local firms. This collaboration will result in knowledge diffusion and an environment that is generally conducive to innovation.

There will be severe competition for high-skilled labour which, in turn, will slow down R&D activities. The amount of high-skilled labour, i.e., PhDs, is inadequate for the R&D demand. As existing graduates are absorbed into the industry, there will be fewer people to join research programmes, thus affecting the supply in the near future.

The hardware industry will grow, especially in semi-conductor fabrication manufacturing. But this growth will be hindered by the lack of support infrastructure, like transport and electricity. Semi-conductor design will grow with great help from the software sector as design capabilities exceed those of manufacturing.

Increased inflow will generate innovation in those ICT segments that cater for the mass market, like travel portals and mobile phones. But growth will be stifled by the rigid policy environment, as India's financial markets are still not completely open.

The telecom growth story must be extended beyond voice to data services. This requires enabling mobile as the delivery platform for data services. The mental image many people have of the Internet involves a desktop (or laptop) computer that is connected by wire (or wirelessly) to an access path of adequate capacity to allow always-on capacity to handle uploads and downloads of data at certain speeds or to a broadband connection. However, there is increasing awareness of the importance of mobiles as an alternative pathway.[29]

The mobile phone has the potential to be a 'platform' that can provide mass access to a wide range of socially and economically beneficial services. Even now, about 117 million mobile subscribers in India are capable of accessing data services, including the Internet, through their mobile handsets**.** Value Added Services (VAS), be they information flows, entertainment, or transactions, have the potential to overhaul personal, professional and

[29] Dutta, S. and Mia, I. (2009). *Global Information Technology Report 2008-09*, *Mobility in a networked world*, Geneva: World Economic Forum and INSEAD; Adler, R.P. & Uppal, M. (2008). *M-Powering India: Mobile communications for inclusive growth*, Washington DC: Aspen Institute.

commercial interactions. VAS also have the advantage of freeing all communications from the hegemony of time and space simultaneously. Low-value commercial transactions for the masses, bridging the gap between the banked and the un-banked, social networking, interaction between citizens and the government, etc. are only some examples of the range of services that can be made available. The advantage of the mobile phone-based system for information is that users are no longer tethered to a limited number of kiosks with PCs but can access the information they need from any location.

For this to become reality, the government should ensure that artificial scarcities of spectrum are not created. Spectrum should be put to the best possible commercial use and hence priced properly. The spectrum management policies of the government, a custodian of the resource, should result in efficient utilisation, optimal revenue generation for the public exchequer, sufficient competition in the telecom market and rapid diffusion of telecom services.

Going forward, India will have to move away from an administratively determined criterion to a market-driven approach for allocation. New UAS licenses should not carry any eligibility for start-up spectrum. A secondary market for spectrum is important in order to do away with the 'winners curse'. In order achieve the optimal number of operators, mergers, transfers and sharing of spectrum have to be permitted which is currently not the case. Steps have to be taken to exploit the digital dividend, which should include a strategic review of spectrum allocation across various bands (both licensed and unlicensed). This will require the government to harmonise ITU-allocated bands and develop policies/plans for the use of spectrum, especially as regards vacating the commercial spectrum that is currently being used by defence.

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APPENDIX A

Table 32: Foreign Direct Investment (FDI) approved in Telecom Sector in India (1 April 2006 –September 2009)

Indian Company	Foreign Country	Activities	Proposed Amount of FDI (Rs. in Crore)	Year of Approval	FDI
Devas Multimedia Pvt. Ltd.	USA	ISP	0.1	April, 06	0.87
Virtela India Pvt. Ltd.	USA	ISP	0.1	April, 06	1
Ramboll Telecom Services India Pvt. Ltd.	Denmark	Consultancy, design and SW development services for telecom sector	1	April, 06	1
AT & T Global Network Services India Pvt. Ltd.	USA	ISP, ILD, NLD	18.5	May, 06	0.74
Matsushita Electric Industrial Co. Ltd.	Japan	Import, export, etc for office automation and telecom products	60	June, 06	1
Reliance Communication Ventures Ltd.	FIIs	CMTS	-	June, 06	0.74
Bharti Airtel Ltd.	Mauritius/FIIs/ OCBs/NRIs	CMTS	1850	June, 06	0.74
Chorus Call Inc.	USA	Tele-conferencing	0	July, 06	0.51
Hutchison Essar Ltd.	-	CMTS	-	July, 06	0.681
e-Citi Infotech Developers Pvt. Ltd.	Mauritius	IP-I	400	November, 06	1
Essar Telecom Linveestments Ltd	Mauritius	Investing company	230	November, 06	0.99
Spice Communications Pvt. Ltd.	Mauritius	CMTS	510.6	November, 06	74%
ATC Tower Company of India Pvt. Ltd.	USA	IP-I	0	December, 06	1
Independent Mobile Infrastructure	Mauritius	IP-I	3000	December, 06	1
Nokia Netword India Pvt. Ltd.	Netherlands	B2 to B2 telecom operators and other customers in India	0	December, 06	1
Idea Cellular Ltd.	FIIs, FVCIs	CMTS	2500	December, 06	0.74
Hair International Co. Ltd.	Hong Kong	Manufacturing of electronics and IT sector	1.1	January, 07	0.51
Worldcom Communications (I) Pvt. Ltd.	Singapore	ISP	5	January, 07	0.74
Reliance Communication Pvt. Ltd.	GDR	CMTS	500	January, 07	0.74
Hayat Communications Pvt. Ltd.	NRI/Foreign	IP-I	0	January, 07	1
India Holdco(Essar Communications)	Mauritius	Investing company (to invest in telecom companies)	500	February, 07	1

Quipo Telecom Infrastructure Ltd.	Singapore UK	IP-I	95	June, 07	65.60%
Cable & Wireless Networks India Pvt. Ltd.	UK	ILD, NLD	0	April, 07	0.74
BT Telecom India Pvt. Ltd.	Mauritius	ILD, NLD	142.6	May, 07	0.74
I-Velozity Inc	USA	Content development	2.3	June, 2007	1
Essar Spacetel Ltd. (Now Vodafone Essar Spacetel Ltd.)	Netherlands	CMTS and UASL	0	July, 07	0.74
Vodafone Essar Gujarat Ltd.	Netherlands	CMTS and UASL	0	July, 07	0.74
Vodafone Essar Cellular Ltd.	Netherlands	CMTS and UASL	0	July, 07	0.74
Vodafone Essar Mobile Services Ltd.	Netherlands	CMTS and UASL	0	July, 07	0.74
Vodafone Essar South Ltd.	Netherlands	CMTS and UASL	0	July, 07	0.74
Vodafone Telecom East Ltd.	Netherlands	CMTS and UASL	0	July, 07	0.74
Vodafone Essar Digilink Ltd.	Netherlands	CMTS and UASL	0	July, 07	0.74
Xcel Telecom Pvt. Ltd.	Mauritius	IP-I	1	7-Aug	1
E-18 Ltd,	Cyprus	ISP	5.6	7-Aug	1
Equant Network Services India Pvt. Ltd.	France	ISP	19.4	7-Aug	0.74
Essar Communications Holdings Ltd.	Mauritius	IP-I	500	7-Oct	1
Sistema Joint Stock Financial Corporation	Russia	UASL	18.7	7-Nov	0.41
Global Assets Holdings Corporation Pvt. Ltd.	Malaysia	Network Services	580	8-Jan	0.49
Ortel Communication Ltd.	Mauritius	Network services	11.28	March, 08	0.71
GTL Infrastructure Ltd.	FCCB	Network services	272.285	8-Mar	0.74
Hathway Cable & Datacom Pvt. Ltd.	Mauritius	Cable TV network	217.25	March, 08	0.37
HAVTEQ Corporation,	USA	Providing digital maps	0.4	8-Mar	1
Vodafone Essar Infrastructure Ltd.	-	IP-I	0	09.05.2008	1
Devas Multimedia Pvt. Ltd.	USA	ISP-Operating-cum-holding	US$ 75 million	29.07.2009	0.7
Marconi Telecom India Pvt. Ltd.	Italy	IT-based services	0	08.07.2009	1
SingTel Australia Holding Pte. Ltd.	Singapore	Internet, IT consultancy services, etc.	0.48	08.07.2009	0.74
ExlServices.com (India) Pvt. Ltd.	USA	Internet and voice-based customer care operations	0	29.07.2008	0.74
Hathway Cable & Datacom Pvt. Ltd.	Mauritius	Cable TV network	43.06	08.08.08	0.43
Aditya Birla Telecom Ltd.	Mauritius	CMTS	2704	26.08.08	0.68

Polcab Wires Pvt. Ltd.	USA	Manufacturing cables	551.05	12.09.08	1
Transcend Infrastructure Ltd.	NRI	IP-I	12.15	12.09.08	1
Essel Shyam Communication Ltd.	CCPS	Uplinking services, VSAT services	92.14	24.10.08	0.49
United Villages Inc	USA	Village-area network (VAN)	0	24.10.08	1
Den Network Ltd.	FIIS, FVCIs, VCF	Cables distribution and Internet services	0	12.12.08	0.49
Equant Network Services India Pvt. Ltd.	Netherlands	ILD/NLD/ISP	0	12.12.08	0.74
Alcate-Lucent India Ltd.	France	Telecom-based services	0	09.01.09	0.67
Tata Teleservices (Maharashtra) Ltd.	Japan	Telecom services	949	09.01.09	0.2
Tata Teleservices Ltd.	Japan	Telecom services	12924	9.01.09	0.26
Bharti Telemedia Ltd.	NRI/OCB	Teleport activity	0	09.01.09	0.48
Pacific Internet India Pvt. Ltd.	Singapore	ISP	15.84	09.01.09	0.74
Telecordia Technologies Inc	USA	MNP solutions	45	23.02.2009	0.74
Tecnomen Oyj	Finland	IT solutions for telecom service providers	131.33	20.03.09	1
Asianet Satellite Communication Ltd.	Mauritius	Teleport activity	0.64	20.03.09	0.48
Tanla Solutions Ltd.	NRI	Production and sale of mobile content and services	31.5	20.03.09	0.5
Broadband Pacenet India Pvt. Ltd.	Cyprus	ISP	17.336	20.03.09	0.45
Tikona Digital Networks Pvt. Ltd.	-	ISP	367.2	19.06.09	0.7
Vodafone Essar Spacetel Pvt. Ltd.	-	ILD/NLD/ISP	0	19.06.09	0.74
Ortus Infratel and Holding Pvt. Ltd.	Netherlands	IP-I	500	19.06.09	1
BGS Smartcard Systems (I) Pvt. Ltd.	-	IT solutions	0	19.06.09	1
Verdant Telemetry	USA	Manufacturing	0.8	19.06.09	0.05
Powermax Communications	USA	Broadband communications network services	0	21.08.09	0.74
Unitech Wireless	Singapore	UASL	3740	21.08.09	0.67
Tecnomen Oyj	Finland	IT solution for telecom service providers	1.3	21.08.09	0.96
Ramboll Singapore Pvt. Ltd.	Singapore	IP-I	3	11.09.2009	1
Sistema Shyam Teleservices Ltd.	Russia	UASL/ISP	0	11.09.2009	0.74
Devas Multimedia Pvt. Ltd.	Mauritius	ISP	0	11.09.2009	70.41%

Source: Lok Sabha Unstarred Question No. 617, dated 23.11.2009. (Downloaded from indiastat.com on 9 May 2010).

APPENDIX B

Table 33: FDI investments in Telecom Sector (major cases) February 2005 to December 2007 (as on 31 December 2007)

S. No.	Name	Location	Nature of Project	Amount invested/ proposed to be invested	Present status
1	(i) Ericsson	Jaipur	Facility for manufacturing GSM base stations and mobile switching equipment	US$ 150 million already invested up to 2006 and additionally in all the 3 centres US$ 200 million by 2008	Factory inaugurated on 11.3.05. Unit in operation: Investment completed
	(ii) Ericsson	Chennai	R&D facility and Global Service Delivery Centre	US$ 100 million already invested	Announced the project at Jaipur on 11.3.05 and factory inaugurated on 25.02.2006. One more facility inaugurated on 27.11.06. Unit in operation.
	(iii) Ericsson	Gurgaon	R&D facility and Global Service Delivery Centre		Announced on 11.03.05. Unit in operation.
2	Elcoteq	Bangalore	Telecom manufacturing	US$ 100 million out of which US $ 18 million already invested.	Factory inaugurated on 11.04.05. Unit in operation
3	LG	Pune and Noida	Mobile handsets etc.	US$ 12 million and additionally US$ 23 million.	Unit in operation Additional investment announced on 16.3.07.
4	(i) Nokia	Chennai	Mobile handset manufacturing	US$ 300 million (with 10,000 employees)	Announced on 06.04.05. Factory inaugurated on 11.03.06. Unit in operation.
	(ii) Nokia	Chennai	To set up Global Network Operation Centre for Customers in Asia Pacific Region, Europe, Middle East and Africa		Announced on 16.12.05. Centre inaugurated on 11.03.06. Unit in operation
5	Aspocom	Chennai	High density interconnections PCB manufacturing plant	US$ 100 million in the first phase and US$ 100 million in the second phase	Foundation stone laid on 04.10.2006. Factory to be operational in the second half of 2007
6	Salcomp	Chennai	Mobile phone chargers	US$ 8 million	Unit in operation in 1st quarter of 2007

7	HonHai (FoxConn) Precision Industry Co.	Chennai	Manufacturing of mobile handsets and components and electronic hardware and related services	US$ 110 million	MoU signed in March, 2006. Land acquired. Under implementation.
8	Perlos	Chennai	Handset mechanics	US$ 12 million	Started in June 2007
9	Laird Technologies	Chennai	Manufacturing of mobile phone accessories	US$ 25 million	Ground breaking in early 2007 and to be operational by mid 2007
10	(i) Alcatel	Chennai	WiMax Centre etc.	US$ 60 million	Centre inaugurated on 03.09.05. Unit in operation
	(ii) Alcatel	Mankapur, U.P.	Technology transfer / revival of ITI	US$ 10 million	Manufacturing recommenced on 07.07.05. Unit in operation
	(iii) Alcatel	Rae Bareli, U.P.	Technology transfer / revival of ITI	US$ 10 million	Manufacturing recommenced on 09.11.05. Unit in operation
11	Samsung	Manesar, Gurgaon, Haryana	Handset manufacturing	US$ 15 million. Additionally expansion Plan of US $ 200 million during 3 years.	Factory inaugurated on 07.03.06 Unit in operation
12	Siemens	Chennai/ Hyderabad/ Kolkata	Telecom equipment manufacturing	US$ 100 million	Announced on 09.08.05.
13	Flextronics	Chennai	Manufacturing of Telecom hardware such as cell phones, set-top boxes, optical networking systems etc. Mechanical and system integration of base stations.	US $ 100 million in 1st Phase US $ 200 million in 2nd Phase	Announced on 14.09.05. Inaugurated on 4.11.06. Unit in operation.
14	CISCO	Chennai	NGN Lab at Chennai; e-Governance networking in IT & telecom across the nation	US$ 1.1 billion including US$ 10 million at Chennai. Investment in IT and Telecom sector across the nation.	Announced on 19.10.05. Under implementation.
15	(i) Motorola	Chennai	Manufacturing of Motorola's first "Made in India" low-cost GSM Phone	US $ 70 million	GSM Phone launched in Delhi on 22.12.05 Unit in operation
	(ii) Motorola	Chennai	Manufacturing of handsets	US$ 100 million (within one year)	MoU signed on 07.06.2006 Announced on 07.06.2006

16	Nokia Siemens Network	Chennai	Wireless network equipment	US$ 100 million	Announced in July 2007
17	Velankani Information System Pvt ltd	Sriperumbedur, Kanchipuram	Electronic hardware & software including ITes	US$ 200 million	SEZ license in May 2007

Source: Department of Telecommunications, Ministry of Communication and Information Technology, Government of India.

APPENDIX C

A. Tata Consultancy Services

Established as a division of Tata Sons (the Tata Group's holding company) in 1968, Tata Consultancy Services (TCS) is one of the pioneers in the Indian ICT industry, especially in the domain of software services. The company has many firsts to its credit. It is the first Indian software company to have won a US assignment; it is one of the first Indian software companies to set up a research and development (R&D) centre; and it is the first Indian software company to have an Offshore Development Centre (ODC).[30]

A.1. Basic facts

Start-up Year:	1968
Products & Services:	Software services, IT consulting and BPO
Employees:	160,429 (2009-2010)
Address:	TCS House, Raveline Street, 21 DS Marg, Fort Mumbai 400 001
	Tel: 022 6778 9999 Fax: 022 6778 9000 Website: www.tcs.com

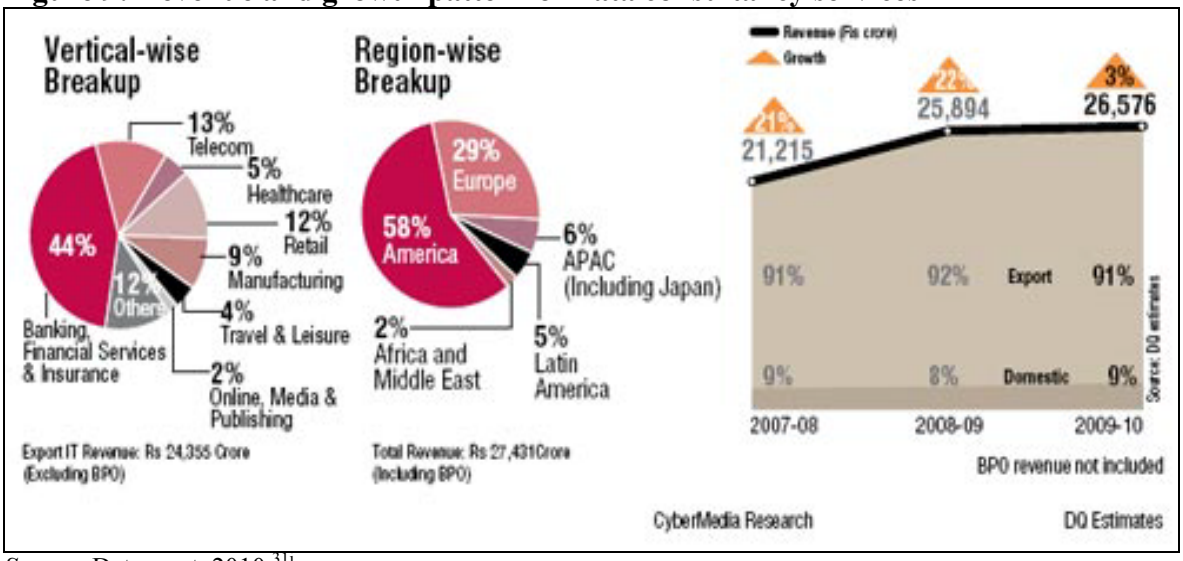
It got listed in the Indian National Stock Exchange in 2004.

A.2. Revenue

Growth of TCS has been quite impressive from INR 21215 cr in 2007-2008 to 26576 crs in 2009-2010. It has been consistently listed within top three revenue generators of the industry by the trade magazines. Growth rate has been in the range of 21% in the period 2007-2010, except in 2009-2010 where it was 3% due to global recession, and the decrease in exchange rates of dollar and Euro. Reflecting the industry trend, 44% of the revenue is generated from banking, financial services and insurance domain followed by 13% of telecom domain. USA constitutes 58% of the revenues in 2009-2010 followed by 25% of Europe (see Figure 9). The Company has 140 offices globally (see Figure 10).

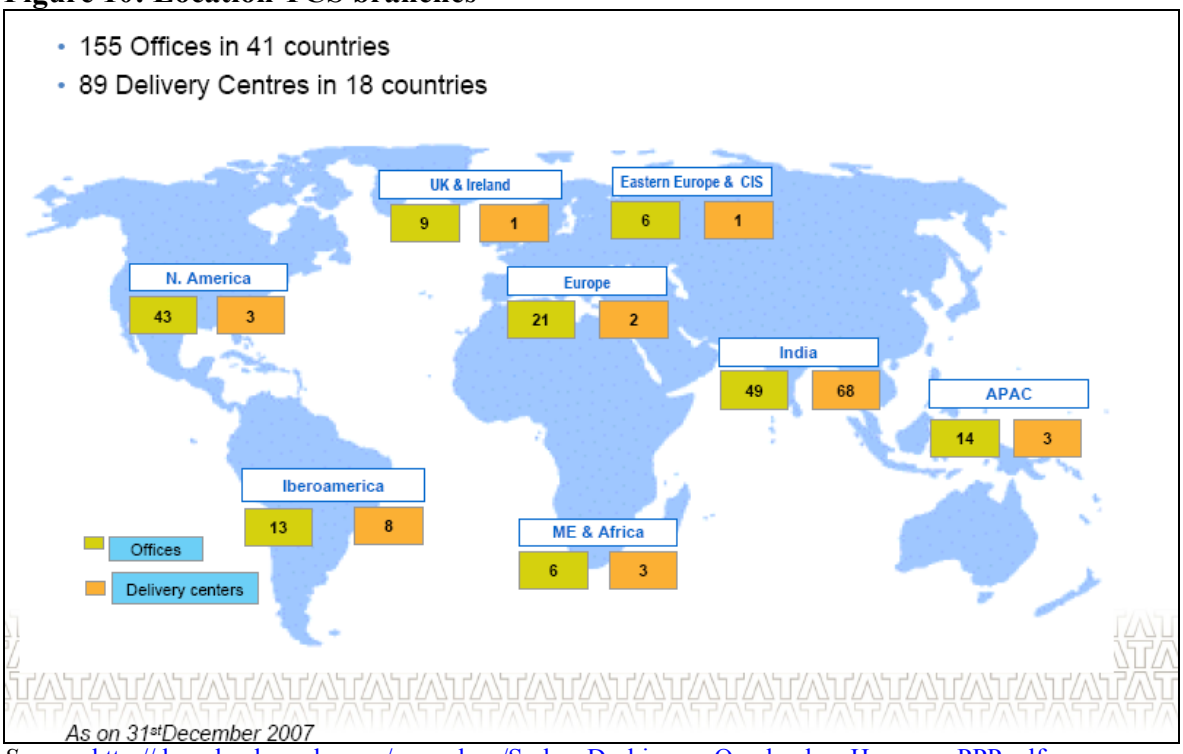
[30] http://www.financialexpress.com/news/tcs-the-pioneer-remains-a-giant/131428/#

Figure 9: Revenue and growth pattern of Tata consultancy services



Source: Dataquest, 2010.[311]

Figure 10: Location TCS branches



Source: http://download.oracle.com/ocomdocs/SudeepDasbiswas_Oracle_day_Hungary_PPP.pdf

A.3. Strategic acquisitions and alliances

TCS has been making acquisitions during the past few years and claims that it is aiming to be one of the top IT companies in the world. During the year 2008-09, the Company has acquired Citigroup Inc (Citi) the India-based captive BPO, for a total consideration of USD 504.54 million 96.26%. The acquired unit is called as TCS e-Serve Limited. The acquisition has broadened TCS portfolio of end-to-end IT and BPO services in the global Banking and Financial Services (BFS) sector.

[31] http://dqindia.ciol.com/content/dqtop20_10/CompanyRanking/2010/110072304.asp

Table 34: Mergers and Acquisitions of TCS

SNo	Year	Company	Business	Country	**Value** in US$ million
1	2008	Citi Global Services Limited	Business Process Outsourcing	India	505
2	2006	TKS-Teknosoft	Banking Product	Switzerland	80.4
3	2005	Comicrom	Banking BPO	Chile	23.7
4	2006	Tata Infotech	IT Services	India	-
5	2005	FNS	Core Banking Product	Australia	26
6	2005	Pearl Group	Insurance	United Kingdom	94.7
7	2006	TCS Management	IT Services	Australia	13.0
8	2004	Phoenix Global Solutions	BPO	India	13
9	2005	Swedish Indian IT Resources AB (SITAR)	IT Services	Sweden	4.8
10	2004	Aviation Software Development Consultancy India (ASDC)	IT Services	India	-
11	2004	Airline Financial Support Services India (AFS)	BPO	India	5.1
12	2001	CMC Limited	IT Services	India	33.8 (51%)

Source: Authors compilation from various trade press reports.

A.4 Human Resource Development

TCS is the largest IT employer in India with more than 126,000 employees and with over 143,000 employees including those in its subsidiaries (2008-2009). TCS reports that there are over 10,500 non-Indian nationals representing 67 nationalities are present in its workforce. Women constitute 30%. As per the annual reports in 2008-2009, the attrition rate was 11.4%.

Being a service oriented company, importance is given to training. In 2008-200, TCS claimed that 1,458,079 learning days were spent on competency development in key technology areas and 11,276 managers at various levels attended leadership development programmes. To widen the reach of Learning and Development globally, 25% of the total efforts was delivered through e-Learning.

Some of the awards received by TCS in 2008-2009 for its human resources practices include:

1. No 1 in the list of best employers & No 2 in list of dream companies in Data Quest-IDCs Best Employer Award.
2. Recipient of Champion of Learning certificate from the American Society for Training & Development (ASTD).
3. Finalist Award for the Best Employee Referral Programme at ERE Expo 2009.
4. Recruiting and Staffing Best in Class Awards (RASBIC), UK.

Training programmes are conducted for the employees both at the entry level as well as the continuous learning programmes covering technology, domain and project management practices.

The total number of person days spent on various learning programmes amount to over 1.6 million and over 22,000 certifications had been completed by the employees on varied technology and products.

TCS has a separate cell within the human resources function is present to ensure compliance to applicable laws and statutes in all the countries that TCS operates.

In 2008-2009, TCS supported 390 technical workshops benefiting about 52,000 students, 131 Faculty Development Programmes benefiting about 4,000 college teachers and internship opportunity for about 1,300 students. It awarded 72 TCS Best Student/Best Student Project Awards to recognize and reward academic excellence - 61 of them in India and 11 of them abroad. Further, TCS also has on-going research alliances with 13 universities - 8 overseas and 5 in India.

A.5. Quality and process assurance

TCS is recommended for enterprise wide ISO 9001:2008 (new version of Quality Management standard) certification and enterprise wide for continuation of the ISO 27001:2005 (Security Management) and ISO 20000:2005 (Service Management) certification.

TCS was re-certified for domain specific quality certification TL 9000 for the Telecom business. TCS also continues to maintain the domain specific certifications AS9100 (for Aerospace industry) and ISO 13485 (for Medical Devices).

Two centres of TCS were re-certified for ISO 14001 (Environmental Health and Safety). Seventeen centres continue to maintain their ISO 14001 certification. Twelve new centres of TCS have also been recommended for ISO 14001 certification.

TCS is the world's first organization to achieve an enterprise-wide Maturity Level 5 on CMMI and P-CMM based on SCAMPISM.

A.6. Research and Development (R&D)[32]

TCS' Chief Technology Office (CTO) and R&D function align closely to support TCS' business objectives. iConnect, the Innovations marketing group, owns the mission of facilitating better communication between the CTO and R&D functions, and all stakeholders inside and outside TCS. The Innovations Go-to-market team supports the sales teams to win new businesses. The Industry Solution Unit (ISU) interface works on creating solutions based on R&D from the Innovation Labs and the Co-Innovation partners. Co-Innovation comes alive for customers in 'Co-Innovation Days' held for each strategic customer.

TCS' Research is focused on enhancing outcomes that customers expect from IT as well as in Business. MasterCraft and other tools have increased efficiency and productivity. TCS' InstantApps Technology, enabling flexible and collaborative application development, has delivered agility and savings. With managed evolution of IT infrastructures, SURe (Sense

[32] Source: http://www.indiainfoline.com/Markets/Company/Fundamentals/Directors-Report/Tata-Consultancy-Services-Ltd/532540

Understand Respond) framework has helped customers reduce complexity and costs. Web 2.0 tools enabled Insurance and retail customers get close to their customers, bringing in innovative business models. TCS continues to help engineering industries with process tools that optimize performance.

TCS' Co-innovation Network ("COIN") has expanded, forging new alliances. Stronger links have been created with Indian Institutes of Technology; work is in progress with several startups on leading edge solutions in GPRS (General Packet Radio Service) and RFID (Radio Frequency Identification) (for asset tracking), Analytics (for Dynamic pricing) Web 2.0 (Enterprise networking and collaboration); TCS' carbon footprint is being studied to further TCS' internal green initiative with several Co-innovation Network partners. Customers are continued to be helped to create their own innovation networks based on TCS' network.

The CTO Incubation Group, focusing on big bets from 'Inception to Implementation' has made good progress with solutions and services in the areas of advertising ecosystems, mobile value-added services and digital devices. The Corporate Tools group promotes the use of tools and enables business units to deliver continuously improving productivity and quality of services to customers.

Internally, TCS CTO and R&D, sponsored several initiatives to foster TCS' culture of innovation. The TCS Top 10 coding challenge open to associates across organizational units in the enterprise, created a buzz among programmers in every region and geography. Web 2.0 platforms such as JustAsk and IdeaMax were deployed to capture tacit knowledge as well as innovative ideas within the enterprise and were adopted eagerly.

The Company's R&D function has grown with the number of PhDs more than doubled[33] and has attracted top talent from notable universities across the world. Further, the research internship programme brings interns from many world class universities.

In 2009, TCS announced that it would fund 200 doctoral candidates over a period of five years to take up Phd programmes in reputable academic institutions across the country. The “TCS Research Fellows” would pursue original research in various aspects of computer science. Forty doctoral or Phd candidates would be chosen as TCS Research Scholars every year from a number of reputable academic institutes through a process of selection conducted by TCS and the academic institutes.

TCS has hosted and participated in several events, creating a rich and interactive environment for the researchers. The 7th TCS Excellence in Computer Science Week (TECS Week 2009) was held at the TCS Innovation Labs with experts of international repute delivering a series of lectures. Senior Researchers from TCS Innovation Labs were a part of the prestigious Stanford Engineering Symposium, India. TCS’ Academic Interaction Meet "Sangam" held its 10th conclave this year and showcased innovation at TCS. The delegates, heads from noted institutions of research and higher education, visited several TCS Innovation Labs. TACTiCS - TCS Technical Architects' Conference, was held in a distributed, "Green" format this year and had over 500 delegates in 4 events held across 35 locations connected by collaboration tools, video conferencing and even a 'Second Life' presence.

The Company's efforts have won many awards. TCS' Mobile Agro Advisory Solution won the Wall Street Journal Innovation Technology Award in the wireless category and the Golden Peacock Innovation Award. Scientists from TCS' Innovation Labs won Tata Innovation Day

[33] Exact figures are not available. According to Jalote (2003), industry majors like TCS employs around 50 people (http://www.cse.iitk.ac.in/acad/doingphd.html).

Awards. Infoworld ranked TCS' Global Certainty IdeaStorm in its list of Top 100 Innovative IT projects. Further, many of the researchers and scientists have won individual laurels and awards.

This year saw greater participation of TCS' CTO and R&D organization in Tata group's innovation efforts: linking up through COIN to Group companies on various projects including ones that helped build visibility like the launch of the social interaction features for the Tata Nano portal. Many of TCS' scientists have been closely involved with Tata CRL's (Computational Research Laboratories) EKA, which was rated Asia's fastest and the world's fourth fastest 'super' computer.

A.7. Patents

Table 35: Details of patents granted during 2008-2009

Sr. No.	Title/Description	Country
1	Method and Apparatus for Pattern based Generation of Graphical User Interfaces (GUI)	USA
2	Method and Apparatus for Batch Programmes Implementation	USA
3	Methods for Aligning Measured Data taken from Specific Rail Track Sections of a Railroad with the Correct Geographic Locations of the Sections	India
4	Selective separation of phosphate minerals from other minerals, using aminotris (methylenephosphonic acid), and diethylenetriaminepentakis (methylenephosphonic acid) as depressants	India
5	A Device for Handling Message Queues	India

Table 36: Expenditure on R&D (2008-2009)

	Year ended in Crs 31.3.2009	Year ended in Crs 31.3.2008
(a) Capital	1.61	1.84
(b) Recurring	42.31	36.94
(c) Total	43.92	38.78
(d) Total R&D expenditure as percentage of total income	0.20%	0.20%

B. Texas Instruments

Texas Instruments (TI) Incorporated, headquartered in Dallas, Texas, is a global, high-technology company with sales and manufacturing operations in more than 30 countries. Texas Instruments' (TI) products and services include semiconductors, defence electronic systems, software productivity tools, printers, notebook computers and consumer electronics products, custom engineering and manufacturing services, electrical controls and metallurgical materials. TI India is one of the most celebrated success stories of offshoring and R&D center in the global ICT industry. To quote:[34] "Today there's hardly a product at TI worldwide, not touched by innovation done by TI engineers in India. In fact, TI and other chip design houses that followed later, from Intel to Cadence, have collectively made India the chip design hub for the world." *Dataquest* and the Government of India have recognized TI as the most innovative company in the country.

In August 1985,[35] TI set up a R&D facility in Bangalore and became the first global technology company to establish its presence in India. Since then, Texas Instruments had crossed many milestones in India. In 1989, it established a design center for mixed signal ICs, and its success inspired the company to set up a design center for application specific products in 1990. The year 1995 saw the launch of a design center for indigenous development of digital signal processor (DSP) cores for applications in hard disk drives by TI customers worldwide. TI opened a center for designing 3G wireless chipsets and WLAN chipsets in 2000, followed by the launch of Pyramid, the SoC design system for worldwide ASIC and all TI businesses in 2001 and OMAP competency centers in 2002. In terms of quality of growth the India center has today become the largest R&D center of Texas Instruments in the whole of Asia. And its scope of R&D is easily comparable to TI's other centers located in Europe, Japan and at its headquarters in Dallas. This way TI has helped tremendously in fostering the R&D culture here and showing the way to other MNCs to leverage India's research skills successfully. Also, its role in the overall welfare and development of Bangalore cannot be overlooked.[36]

TI India is deeply involved in developing state-of-the-art solutions for applications like wireless handsets, wireless infrastructure (base stations), video (security and surveillance, IP phones, set-top boxes), High Performance Analog, etc. Today, there is hardly any chip produced by TI that is not touched by engineers at TI India.

Since 2006, in addition to being a significant and critical R&D center for TI globally, TI India has increased its focus on the Indian semiconductor market in a big way. The company is working closely with its customers in India in a wide array of sectors such as industrial electronics (UPS, inverters, energy meters, lighting, etc.), medical electronics (ultrasound scanners, x-ray machines, ECG machines, MRI scanners, etc.), consumer, telecom and automotive. TI India has opened offices in multiple locations in the country to reach out to its customers with sales and applications support.

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34 http://economictimes.indiatimes.com/features/corporate-dossier/Texas-Instruments-Growth-with-work-centering-around-low-cost-innovation/articleshow/6482066.cms

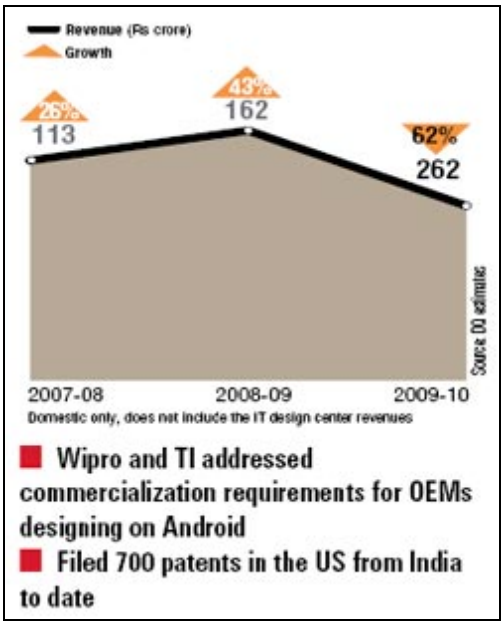
35 http://www.ti.com/ww/in/company_info.html

36 http://dqindia.ciol.com/content/50yrsIT/Trailblazers/2006/106123001.asp

B.1. Basic facts[37]

Indian Managing Director:	Bobby Mitra
Start-up Year:	1985
Products & Services:	Analog and digital chip design and applications software, SOC, microcontroller and signal processing technologies
Address:	Bagmane Tech Park, No 66/3, Raman Nagar Post, Bengaluru 560 093.
Employees:	1,400
Tel:	080 2534 5455 - Fax: 080 2534 5355
Website:	www.ti.com/ww/in

Revenue growth:



B.2. Collaborations with Indian universities

TI helps with Indian universities in building skilled labour pool in the area of Digital Signal Processing. UniTI stands for "Universities and TI". UniTI is a mutually beneficial relationship between academia and industry in the field of digital signal processing, and is the forum in which TI India interacts with universities and interested technical institutions in the role of a facilitator.

Texas Instruments India works with universities to achieve multiple objectives:

1. Promotion of TI company image amongst faculty and students on campus,
2. Seeding of TI technology skills amongst large numbers of future technology industry engineers,
3. Support of faculty / research staff in the outsourcing of industry R&D to universities on TI platforms,

[37] BOP ranking & emerging segments, Company rankings, Data Quest: http://dqindia.ciol.com/content/dqtop20_10/CompanyRanking/2010/210072610.asp (accessed on 15 November 2010)

4. Support of campus product incubators that are building innovative products on TI platforms.

TI views its engagement with each university as a win-win relationship for the institute, faculty, research staff, students and TI. Although TI directly is able to engage just a few universities in India, via its university distributor and partners in India TI extends its reach to potentially all engineering institutes in the country, and offers all the elements that are required to successfully set up TI-DSP-based education programmes in any engineering institution.

TI's university programme in India, in terms of its 500+ operational TI DSP labs (Mar 2006) at over 450 Indian engineering institutions, is TI's largest university programme worldwide.

From 2005-06, TI has been actively promoting MSP430, High Performance Analog and VLSI Design education at universities in India. TI is actively working with state universities across India to strengthen the VLSI (Digital and Mixed Signal) Design curriculum available to faculty and students across a large number of engineering colleges. This effort is being undertaken through select channels to achieve a goal of 10,000 annual VLSI-specialized graduates and 2,000 experienced VLSI faculty in India by 2008.

B.3. TI design contests

TI annually conducts a DSP design contest across all engineering colleges in India. Students are required to register for the contest at the start of the year. Complete designs submitted to TI are evaluated on the basis of innovation, technical completeness, business applicability and quality of submission. The winning teams receive financial awards and the winning team presents its design to the full audience at the *TI India Developer Conference* at the end of the year.

From 2006 TI is also facilitating design contests open to students within each engineering college in India for projects undertaken on TI DSP, MSP430 and HPA silicon, and for projects in VLSI design. These contests will be facilitated only at colleges providing corresponding classroom/lab training in these areas.

TI has collaborations with all the premier educational institutions (see the figure below) indicting the reach of the firm in the country.

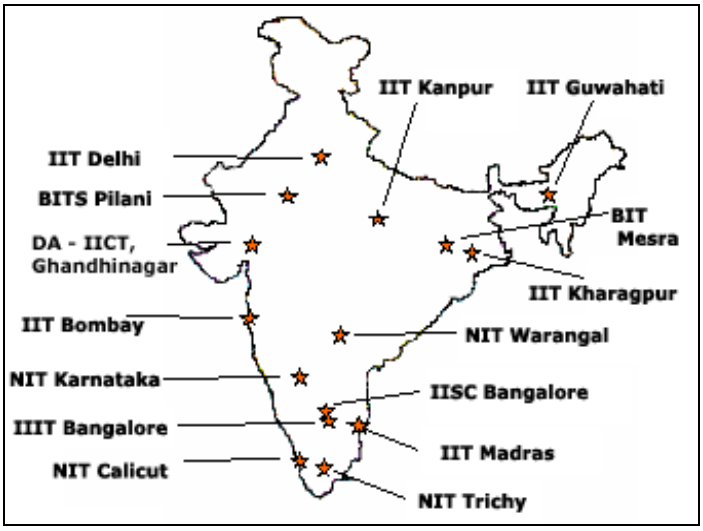


Figure: TI's linkage with Indian institutions.
Source: http://www.ti.com/ww/in/university_prog.html

B.4. R&D

India TI center is supposedly to be an extended arm of the TI's R&D center. As of 2007, it has the highest number of US patents in India, 485 and has contributed more than 1000 papers in the international conferences.[38] Following are some of the recognitions received by TI India:

- ⇨ 1999 - EDN Asia Component Design Award for "Ankoor"
- ⇨ 1999 - EDN Innovation of the Year Award " xStream DSP"
- ⇨ 1999 - EDN Top 100 Product of the Year Award "THS1206 ADC"
- ⇨ 1999 - EDN Innovation of the Year Award "eXpress DSP"
- ⇨ 2000 - EDN Asia Component Design Award "TLFD600"
- ⇨ 2001 - EDN Asia Innovator of the Year Award
- ⇨ 2002 - EDN Asia Innovation of the Year Award "Malhar"
- ⇨ 2003 - MAIT Award for Excellence in Innovation
- ⇨ 2003 - #1 Company to Work for in India – Business World
- ⇨ 2004 - #2 Company to Work for in India (Behind FedEx), Business World
- ⇨ 2004 - STPI Award for Exports
- ⇨ 2005 - Dataquest Award for most Innovative Company
- ⇨ 2005 - EE Times Annual Creativity in Engineering (ACE) Award - Single Chip Cell Phone Processor
- ⇨ 2006 - Semiconductor INSIGHT Award: single-chip mobile phone platform - Most Innovative Baseband and/or Applications Processor
- ⇨ 2006 - EDN Top Programmable Embedded Processor of the Year Award for Antara
- ⇨ 2006 - PC Magazine's annual Technology Breakthroughs! TI OMAP3430
- ⇨ 2007: STPI Award for #1 in Semiconductor Exports
- ⇨ 2007: NASSCOM Award for IT Innovation.

B.5. Innovation

In August 2005, Texas Instruments chairman, Thomas J Engibous on his India visit made a phone call from India to Europe on a live cellular network using the industry's first single chip solution for ultra low cost handsets. This new chip targeted for developing economies—appropriately named LoCosto—was designed across various R&D sites of TI, with the India center steering the development. The company's engineers integrated the functions of the digital, analog and high frequency RF chips onto a single one in order to bring down the price of a cell phone, and increase battery life significantly. Several key wireless OEMs are already using these in phones sold in countries including China, India and Eastern Europe.[39]

The parent firm has invested $2.2 billion in 2006 in R&D worldwide as against $1.3 billion in capital expenditure. With 31,400 employees, it has manufacturing, design and sales operations in 25 countries worldwide. Data on India center, especially on amount of investment made, is not available. A trade press report says that in 2003, TI planned to invest $ 100 million in the R&D center.[40]

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[38] http://www.slideshare.net/nasscom/nasscom-innovation-awards-2007-santosh-kumar-general-managermistral-software (Accessed on 15 November 2010).

[39] http://www.thesmarttechie.com/magazine/printarticle.php/KOBH275331013 (Accessed on 15 November 2010).

[40] http://www.financialexpress.com/news/texasinstrumentsbetsbigonr&dinindia-toinvest100m/79734/# (Accessed on 15 November 2010).

As an integral part of TI's global engineering teams, the subsidiary works with global corporations, India's top 100 and SME (small and medium enterprises) for locally designed products in communications and industrial space. Through a third party programme, more than 50 local firms are working with the TI scientists in developing intellectual property blocks.[41]

B.5.1 Ankur[42]

Ankur originally designed for motor control applications for hard disks is still in production. Variants of the chip are used in multiple HDD (hard disk drive) designs. Some of the applications built around Ankur chips include industrial drives, motor control, digital power supplies, renewable energy, power line communication and electric power steering applications.

B.5.2 Sangam[43]

This system-on-a-chip (SoC) is the outcome of questioning the possibility of integrating all the chips—the network processor, DSP, analogue front-end, line driver and power management—to create a single chip solution for a DSL modem. Sangam is unique in many ways. It is the first chip manufactured by the company to have a significant analogue component integrated into its digital circuitry. It is also the first such project in the DSL space to be executed anywhere in the world.

[41] http://www.hindustantimes.com/Texas-Instruments-to-focus-on-R-amp-D-in-India/Article1-213089.aspx (Accessed on 15 November 2010).

[42] http://economictimes.indiatimes.com/features/corporate-dossier/Texas-Instruments-Growth-with-work-centering-around-low-cost-innovation/articleshow/6482066.cms (Accessed on 15 November 2010).

[43] http://www.expresscomputeronline.com/20030721/newsan1.shtml (Accessed on 15 November 2010).

European Commission

JRC 64578 – Joint Research Centre – Institute for Prospective Technological Studies

Title: Trends in Public and Private Investments in ICT R&D in India

Authors: Payal Malik and P. Vigneswara Ilavarasan

Luxembourg: Publications Office of the European Union
2011
Technical Note

Abstract

The Information Society Unit at IPTS (European Commission) has been investigating the Information and Communication Technologies (ICT) sector and ICT R&D in Asia for several years. This research exercise led to three reports, written by national experts, on China, India and Taiwan, each one including a dataset and a technical annex. This report covers India.

The report describes the Indian ICT sector, and gives a company level assessment. It also analyses Indian ICT R&D strategies, and assesses the innovation model.

Information and Communication Technology (ICT) is an important emerging sector in contemporary India. The Indian ICT industry contributes to the national economy in many ways and almost all the Indian states are targeting the ICT sector as a vehicle for economic development. This sector employs about 2 million people directly, with indirect employment projected at four times direct employment. The Indian ICT sector is growing in all domains, but is predominantly driven by software services. Here growth is driven by services – a real "service revolution" with unusual innovations. Since the Indian ICT sector concentrates on services, innovation is predominantly on processes.

The domestic industry is expected to grow faster as ICT expenditure by the other industrial sectors increases. The presence of a domestic market of critical mass is crucial for the long-term growth of the firms and the industry. However, the small size and low income potential of the domestic sector force firms to depend exclusively on the export market, making this sector more vulnerable to foreign market and policy fluctuations.

The mission of the Joint Research Centre is to provide customer-driven scientific and technical support for the conception, development, implementation and monitoring of European Union policies. As a service of the European Commission, the Joint Research Centre functions as a reference centre of science and technology for the Union. Close to the policy-making process, it serves the common interest of the Member States, while being independent of special interests, whether private or national.