7. SECTORAL INNOVATION SYSTEMS IN DEVELOPING COUNTRIES

The case of ICT in India

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7.1. Introduction

Last two decades witnessed a major shift in the development strategy among developing countries. The change implied a move away from import substitution with a more activist role for the state in almost sectors of the economy to an outward oriented strategy with prime role for the market forces. Initial impetus to such a shift presumably has been provided by the miraculous growth performance of South East Asian countries that was attributed to outward oriented policies and reduced role of government intervention. The process got accelerated with the formation of WTO wherein the developing countries, under various multilateral agreements, apart from liberalizing their trade and investment regime, had to make various commitments with respect to public investment, fiscal reform, intellectual property rights and others. The outcome has not been very encouraging for many developing countries. While some of the Asian countries like China, India have

managed to improve their growth performance, most of the countries in Latin America and Sub-Saharan Africa had to be contended with “lost decades” (Wade, 2004, Sanchez, 2003, Rodrik 2005, World Bank 2005 among others). The disenchantment with the development experience during the last two decades resulting from the unequal integration into the world economy has brought the issue of catch up - the process by which the gap in development with respect the leading countries is reduced (Fagerberg and Godinho, 2005) - to the fore.

The development experience of most countries indicate that the catching up process is associated with the emergence and growth of some leading sectors that in turn contribute, both directly and indirectly, towards the development process (Malerba 2002). Therefore, in addressing the issue of catch up, which is quintessentially at the core of development problem, much could be learned by analyzing the problem from a sectoral perspective. In this context it may be inspirational for other countries in the South that a developing country like India has acquired significant capabilities in Information Communication Technology sector (ICT) - the General Purpose Technology of the new millennium, instrumental in enhancing efficiency, competitiveness and growth in all economies and help achieving the millennium development goals by the developing countries - and has immensely profited from its production and export. No wonder, many a developing countries and other sectors within India, are looking for plausible lessons for emulation. The point is further reinforced by the unprecedented increase in the number of bilateral cooperation agreements between India and other developing countries in the recent past wherein the ICT component has been at the center stage.

There is no claim that the experience of ICT sector in India is the only such episode in the developing world. There are many such sectoral instances from other developing countries (see Malerba 2006) worthy of emulation and drawing valid inferences. Drawing lessons, effective emulation and implementation, however, are easier said than done, as the sectors vary not only in terms of the nature of innovations and the dynamics and transformation but the context in which such changes take place. Thus viewed, while a sectoral system in developing countries might broadly adhere to the different dimensions – knowledge, technological domain and boundaries, Agents, interaction and networks, and institutions - as identified by Malerba (2005), there could be significant differences with respect to each of these dimensions for sectors operating in a developing country as compared their counterparts in the developed world. What is more, The challenge of innovation scholars dealing with sectoral systems in developing countries is therefore to highlight the unique characteristics in the South such that much could be contributed towards the informed policy making.

This chapter, by highlighting certain unique characteristics as well as new challenges and opportunities faced by the sectoral systems in developing countries, argues that the extent of success that countries like India have achieved in sectors like ICT is crucially dependent on how the sectoral innovation systems evolved over the years. The remainder of the paper is organized as follows. The section 7.2 presents the broad analytical framework of sectoral innovation systems in a southern perspective and also highlights certain new challenges and opportunities. The section 7.3 examines the major elements of ICT sector in India and its dynamics followed by the last section wherein the concluding observations are presented.

Box 7.1. Sectoral Innovation Systems in Developing Countries: main terms used in this chapter

SSI = Sectoral System of Innovation = it is a system "composed of a set of agent carrying out market and not market interactions for the creation, development and diffusion of new sectoral products (Malerba, 2005, p.65)

Building blocks =key elements of a sectoral systems: actors (firms and other agents), networks, institutions (including policy regimes), technologies and knowledge. (Malerba, 2002, 2005)

ICT = Information and Communication Technology

Outsourcing = it is when a company hands off to other firms activities and functions that could be or have been provided in-house

Offshore = the relocation of activities and functions to foreign countries

7.2. Sectoral Innovation Systems: A Southern Perspective

The *sectoral system* framework, according to Malerba (2002, 2005) focuses on the nature, structure, organization and dynamics of innovation and production in sectors with following building blocks; actors (firms and other agents), networks, institutions (including policy regimes), technologies and knowledge. In a recent paper Malerba (2006) also argued that the factors instrumental in catching up may drastically differ across sectors. In what

follows, following Malerba (2005), we shall briefly discuss each of the building blocks and make an attempt to examine how they differ in a typical developing country in contrast to the developed countries.

7.2.1. Building Blocks of Sectoral Innovation Systems

In any sectoral systems the firms, as units primarily responsible for the transformation of inputs into outputs, are the prime actors. Notwithstanding the variation in terms of their characteristics like size, ownership, organisation and others, they are characterized by specific learning processes, competences and organizations, as well as beliefs, expectations, and goals (Nelson and Winter, 1982; Malerba, 1992, Teece and Pisano, 1994, Dosi, Marengo and Fagiolo, 1998, Metcalfe, 1998).

In addition to *firms*, a sector is composed of other agents that are organizations or individuals. Organizations may be suppliers, users, producers, universities, public research laboratories, financial institutions, government agencies – dealing with promotion and regulation, trade-unions, or technical associations. Individuals may be consumers, entrepreneurs, scientists and others. Agents are characterised by specific learning processes, competencies, beliefs, objectives, organisational structures, and behaviors. Agents interact through processes of communication, exchange, cooperation, competition, and command.

Regardless of the sector, firms are linked either through network. The evolutionary approach and the innovation systems literature have also stressed wide range of inter-firm interactions and that between firms and knowledge generating agencies like the universities

and public research laboratories. Relationships between firms and non-firm organizations (such as universities and public research centres) have been a source of innovation and change in several sectoral systems including pharmaceuticals and biotechnology, information technology, and telecommunications (Nelson-Rosenberg, 1993). The types and structures of relationships and networks differ greatly from one sectoral system to another on account of the varying knowledge base, learning processes, technologies, the characteristics of demand and the dynamic complementarities.

Institutions include policy regimes, norms, routines, established practices, rules, laws, standards, and so on. Institutions may range from ones that bind or impose enforcements on agents to ones that are created by the interaction among agents (such as contracts); from more binding to less binding; from formal to informal (such as patent laws or specific regulations vs. traditions and conventions). A number of institutions are national (such as the patent system), while others are specific to sectors (such as sectoral labor markets or sector specific financial institutions). In all sectoral systems, institutions play a major role in affecting the rate of technological change, the organization of innovative activity, and performance (Malerba 2006). They may emerge either as a result of deliberate planned decision by firms or other organizations, or as the unpredicted consequence of agents' interaction. Often, the characteristics of national institutions favor specific sectors that fit better the specificities of the national institutions. Thus, in certain cases, some sectoral systems become predominant in a country because the existing institutions of that country provide an environment more suitable for certain types of sectors and not for others[1].

Each of the sector is characterised by a specific knowledge base in relation to products and process involved. Kknowledge plays a central role in innovation and affects the types of learning and capabilities of firms. Knowledge is highly idiosyncratic at the firm level, does not diffuse automatically and freely among firms, and has to be absorbed by firms through their differential abilities accumulated over time. The evolutionary literature has proposed that sectors and technologies differ greatly in terms of the knowledge base and learning processes related to innovation. Knowledge differs across sectors in terms of domains. The sources of technological opportunities markedly differ among sectors. As Freeman (1982) and Rosenberg (1982), among others, have shown, in some sectors opportunity conditions are related to major scientific breakthroughs in universities. In other sectors, opportunities to innovate may often come from advancements in R&D, equipment, and instrumentation. In still other sectors, external sources of knowledge in terms of suppliers or users may play a crucial role. In general, the features and sources of knowledge affect the rate and direction of technological change, the organization of innovative and production activities, and the factors at the base of firms' successful performance (Malerba 2006).

7.2.2. Sectoral Innovation Systems in the South

To the extent that the institutional contexts, as well as the behaviour of firms and other agents along with the networks and the interaction between the elements therein are different in the developing world, the nature as well as the innovative outcome in sectoral systems is likely to be different from the developed world. The real challenge for

innovation system researchers in developing countries is, therefore, to highlight the, nuances at the level of actors, networks, technologies and innovations.

Let us begin with the nature of technological change and the process involved with some attention to the inducement mechanism and focusing devices. Prior to the "innovation system revolution" there existed a growing body of literature on technological change in developing countries (Cooper 1980, Bell et al 1982, Bell and Pavitt 1992, 1997, Dahlman 1984, Fransman 1986, Katz 1984, Lall 1982, 1987, Dahlman and Westphal 1982 to list a few) and have thrown up rich insights. These studies, among others, have highlighted two different, but interrelated, processes of technological capability building. The first one related to the transfer of technology. This takes various forms and mechanisms like Foreign Direct Investment (FDI), technology licensing and capital goods imports which are market mediated with active role to foreign firms to transfer of knowledge through imitation which is non-market mediated and with passive role for the foreign firms in the developed countries (Dahlman and Westpal 1982). The second process has been the domestic R&D effort, mostly adaptive in nature.

Regardless of the mode of transfer, the technology acquired from the developed countries needed several types of adaptations for use in the developing countries. As Nelson and Winter (1977) pointed out, technological knowledge, because of its complexity, cannot be transferred in its entirety. The result is that the purchaser of technology always receives less complete information set than what is possessed by the seller. This forces the technology importing countries to develop local technological capability through R&D effort. Moreover, since the

technology imported has been generated in the developed economy context the effective use of technology transferred called for adaptations to suit the local conditions like the need to scale down technology (Katrak 1985) unavailability of the needed raw materials and spares (Page Jr 1979, Katz 1980, Desai 1984) or the need to diversify the products and to increase the capacity utilization. This induced the firms to undertake domestic R&D, mostly adaptive type, leading to incremental innovations as opposed to the Schumpeterian type discrete random jumps in technology.

Such innovative efforts by firms and other actors in developing countries take place in a context wherein the institutions, that are shown to be important in influencing the innovation process, are either practically absent or at their early stage of development. The bearing of such weak institutional structures in the South is bound to influence the behavior of firms, other actors and networks in a way different from what was observed in the North. This may be manifested among others in the weak, or rather non existent, interaction between universities/public research laboratories and the firms, reliance on foreign technology spillovers while domestic generating efforts get adversely affected by brain drain especially in the early stages. The structural characteristics also inhibit complementary innovations that in turn lead to lopsided development. Thus one could have a sector that primarily caters to the world market while domestic use remains limited on account of the lack of complimentary capabilities. Similarly, emergence and growth of one sector might also lead to the weakening of certain other sectors that are crucial to the sustained development the former[2].

Empirical evidence across countries in the South also indicates that the elements of sectoral system that were instrumental in the sectoral dynamism and transformation varied from sector to sector and country to country. While the crucial factor behind catch up in sectors like electronics in Taiwan has been learning and capabilities of domestic firms uunder the weak patent regime, (Amsden and Chu 2003), role of the government has been highlighted in the case telecommunications in Brazil (Mani, 2004), software in India (Joseph 2002, 2006) and aircraft in Brazil (Dahlman and Frischtak 1993 and Viotti 2002). In several sectors, Mazzoleni and Nelson (2006) have shown that universities and public research laboratories performed advanced research and trained human capital, which were important as the experience of several countries indicate. The catch up process of countries in different sectoral systems has also been affected by the specific types of networks. In some sectoral systems like electronics, as argued by Lundvall (1993), vertical networks with suppliers have provided new inputs and shared relevant information for production and innovation, and led to learning and capability development by domestic firms. In the context of global production networks, studies have also shown that specialization in different stages of the global value chain has been another way to catch up (Gereffi et al. 2005, Ernst, 2002, Morrison, Pietrobelli and Rabellotti, 2006). While the large and growing domestic demand has been relevant to catch up for most sectors in countries like China, the world market and export has played a major role in catch up in small or medium size countries. These differences as argued by Malerba (2006) has to be seen against the fact that sectors are not homogenous and are characterized by different technologies, actors, networks and institutions. There is also evidence to suggest that within the same sectoral system, countries may exhibit differences in the factors that drive the catch up process. This

is due to differences in national innovation systems, different specialization within sectors or within the global value chain, presence of specific actors or to “historical accidents” with path dependent processes.

These are important insights in understanding the sectoral dynamics in terms of their innovation and production process. However, from the perspective of developing countries, one also needs to reckon with the new international environment in which they operate With the removal of trade barriers the domestic firms, regardless of the sector in which they operate, are exposed to international competition and that the infant industry protection and government subsidies widespread in most of the earlier catch up episodes at best have very limited role today. The unprecedented exposure to international competition in turn has had their influence on their innovative behaviour and competitive strategies of local firms. This has been manifested in the increasing incidence of joint ventures and takeover of local firms by foreign firms. Similarly, the strong intellectual property right regime being imposed on the developing countries of toady entails an environment significantly different from the ones that was confronted earlier. Today there is little scope for reverse engineering and duplicative imitation based innovation strategies widespread in the earlier regime. Also the role of university industry interaction that has had significant role in catch is likely to have limited role as there has been significant cut is social sector expenditure in a context wherein countries are forced to adhere to fiscal prudence by reducing their fiscal deficits. Under the new environment the observation that countries that are technologically backward have a potentiality for generating growth more rapid than that of more advanced countries Abramovitz (1986) may not be as applicable as it has been earlier. Therefore,

under the new disposition, the basic building blocks of the sectoral systems, as articulated by Malerba while remain in tact, might exert their influence in a way different from the earlier catch up episodes. Hence any analysis of the sectoral system of innovation in the developing countries without due attention to these challenges is likely to depict a picture far from reality.

At the same time, the developing countries also have access to new opportunities. In the context of heightened international competition MNCs have been forces to establish of global production networks, wherein they look for locations that supplement their core competence. This has opened up new opportunities for specialized suppliers with certain capability sets. The nature of outsourcing requirements have increased to include high-end services like product design, engineering and R&D (Ernst and Lundvall 2000). The global dimension of the sectoral system of innovation has become crucial in understanding the dynamics of upgrading and innovation of certain industries in developing countries.

In this chapter we focus on the ICT sectoral system of innovation. ICT play a fundamental role in the development world for two reasons. First, the whole process of internationalization has been facilitated to a great extent by the spread of information technology. Second, it has also been shown that ICT, by enhancing both the incentives and possibilities for codifying knowledge (David and Foray 1995) could be instrumental in influencing catch up through its bearing on learning and competence building process. Though the local capabilities to use or the competence to access knowledge varies widely, the access potential exists and that ICT brings to the forefront the enormous potential for

catch up (Soete 2006). Soete also stressed the role of tacit knowledge and other competence elements in the capacity to access international codified knowledge. Ernst and Lundvall (2000) though underlined the complexity in the connection between IT revolution and the learning economy, felt that the main impact of IT is not to reduce the importance of tacit knowledge, but to facilitate the massive transfer of tacit knowledge into information systems that gives developing countries access to new recipes (process knowledge as well as new products) developed in the rich countries at a lower cost implying an acceleration of the catch up process and prospect for narrowing global inequalities.

7.3. Building blocks and Dynamics of India's ICT Sectoral System

With respect to most indicators, India's IT software and service sector has been showing remarkable dynamism. The value of output of India's software and service sector increased from less than $ 0.83 billion (0.8% of GDP) in 1994-95 to $ 36.3 billion (5.2% of GDP) in 2005-06 (NASSCOM 2006). According to NASSCOM surveys the software industry employed 284,000 people in 1999-00 as compared to 160,000 professionals in 1996 and reached a level of 1.29 million in 2005-06 recording an annual compound growth rate of over 35 per cent[3]. The observed growth was driven mostly by exports. The share of exports in total revenue increased from less than a third to more than three quarters during 1985-2006 and the trend continues. More precisely, the recorded annual compound growth rate in export has been over 50 percent in the 1990s and 38 per cent since 1997-98 and such a record has been unprecedented. Needless to say the remarkable export performance has

attracted the attention of researchers and well documented in the literature (Schware 1987, 1992, Heeks 1996, Kumar 2001, Arora et.al 2001, Joseph and Harilal 2001, Parthasarathi and Joseph 2002, Joseph 2002, Nath, and Hazra 2002, Athreye 2005, Kumar and Joseph 2005 to list a few). The software export performance becomes more striking when compared with that electronic hardware exports. While software accounted for only about 22 per cent of total electronics exports in 1985-86, it increased to 92 per cent in 2005-6 (see Fig 7.1). What is more, the export performance of software and service sector and its presence in over 170 countries and customer base that include most of the fortune companies along with large scale take over of foreign IT firms by Indian firms appears to have contributed significantly towards enhancing India's credibility in the world market. It has also been shown that the organizational, managerial and other innovations introduced by the IT firms are increasingly being emulated by firms in other industries contribute to their enhanced performance (Arora and Athreye 2002).

[Fig. 7.1. about here]

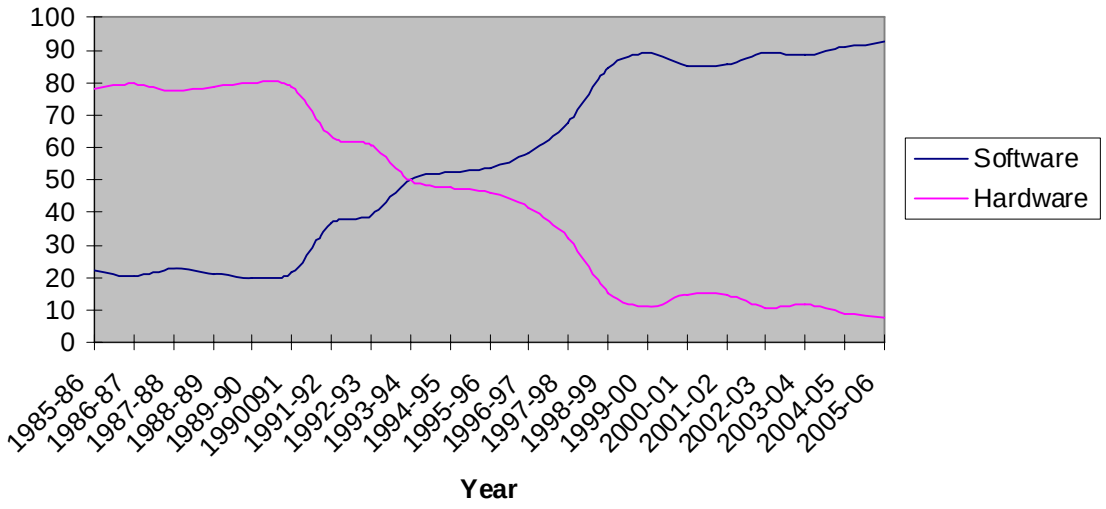

Fig 7.1: Share of Software and Hardware in IT Exports

Having established credibility in the export of software services, of late the Indian firms have emerged as the major players in business process outsourcing (BPO) through Internet or the so-called IT Enabled Services (ITES). The ITES/BPO services, experiencing a boom at present, have certain characteristics that could contribute to broad based development. While employment in the Software sector has been mainly for the highly skilled IT professionals, the ITES sector generates employment for the arts and science graduates as well. It is also found that ITES sector is more employment intensive with employment per million dollars of exports as high as 70, which is more than twice that of the software sector (Joseph 2006). No wonder with 27 per cent of the total exports ITES sector generates as much employment as the software sector. Thus viewed ITES/BPO appears to have the potential of generating substantial employment for the growing number of educated youth

in the country. While software industry in India is shown to have led to an enclave type development (D'Costa 2003) the ITES is found geographically diffused across different regions in the country and generating more linkages with rest of the economy. Hence for those regions, which were not successful in attracting software investment, ITES offer an alternative. Accordingly, different state governments have initiated policy measures to attract ITES activity into their states with considerable success.

7.3.1. The Building blocks of India's ICT Sectoral System

To have a better understanding on the dynamics of the sectoral system of innovation, let us start by exploring in some detail the sectoral innovation system in the ICT sector of India following Malerba (2002) with focus on its key elements like the policy regime, Firms and other actors, and networks related in particular to R&D activities.

Policy Regime

To begin with let us examine the policy measures that facilitated emergence and growth of software and service sector in the country. It has been argued that single most important factor that led to the emergence of internationally competitive software and service sector in India has been the availability of skilled manpower at highly competitive rates (Heeks 1996). However, there many other sectors wherein India has such absolute advantage but with limited success. Hence, as argued by Athreye (2005) India's success, apart from the absolute cost advantage, has been due to higher labour productivity in the software sector.

Estimates by Athreye shows that labour productivity in software has been more than twice than in manufacturing in India as compared to 1.3 times in the United States.

In creating these initial conditions the state policy played an important role that has been well documented (Heeks 1996, Kumar and Joseph 2006 Athreye 2005). Government in the early 1970s anticipated the need for developing manpower in computer science and called for specialized Masters level programmes at the IITs and other major institutions. Also anticipating the future needs, proficiency in computer programming was made mandatory for the undergraduates of IITs and science postgraduates of all major universities in the country. As a follow up of these recommendations, M.Tech (2 year post graduate) and B.Tech (4 years graduate) courses in computer science were started in 1974 and 1977 respectively with DoE support at the IITs. In 1982, two new courses viz. a three year Master of Computer Applications (MCA) and a Diploma of Computer Applications (DCA) were started besides expansion of M.Tech/ B.Tech courses as a follow up of the Rajaraman Committee of 1978. These facilities were further expanded and new polytechnic diplomas were started in 1984 further to Computer Manpower Development Programme launched in 1983 (Kumar and Joseph 2006). In 1984, Sampath Committee reviewed the training needs and in 1985 a Standing Committee on Computer Education was set up to plan further actions. The new courses introduced under the Computer Manpower Development Programme supported by DoE at about 400 institutions had produced some 15000 software personnel by 1996 (Heeks, 1996). The DoE's support has not been restricted to financial grants but has also involved curricula development. Besides the courses started at the educational institutions, a number of enterprises and other institutions promoted by DoE

have also been providing training in software development. These include NCST and C-DAC running advanced software engineering courses and CMC Ltd., ETTDC, NIC running routine software application training.

Government also permitted private investment in IT training since the early 1980s. About 80 private companies have been operating some 4,000 training centers by 2000 offering various IT courses throughout the country through networks of franchises[4]. These privately run centres offer diplomas of various duration, ranging from short-term specialized courses to longer-term basic courses. Some of these private companies expanded their training outside India and by 2004 Indian firms were found offering IT training in 55 countries. What is more, the leader NIIT has been operating more than 100 training centers in China.

However, the quality of the training imparted by these institutions had been uneven. DoE has stepped in to provide accreditation of their courses as a step towards standardization of these courses. A scheme called DOEACC was started in 1990 to provide accreditation to specified level of courses viz., O-foundation course, A-Advanced Diploma, B-MCA Level, C-M.Tech Level. DOEACC Society accredited about 699 institutes by January 2000. The Society conducts examinations for all the four levels twice a year and grants certificates /diplomas (Kumar and Joseph 2006).

The demand for software personnel especially engineering graduates has grown rapidly since the mid 1990s due to the expansion of the software development activity in India as

well as the growing brain drain. In view of this, easing the supply of IT professionals has been one of the challenges faced by the country. In a survey conducted during the late 1990s, 57 per cent of the firms interviewed indicated manpower and skills shortage as the major problem (Arora *et al*. 2000). In a context of IT manpower shortage the National Task Force on IT and Software Development (NTITSD) made a number of recommendations for augmenting the quality and quality of trained manpower for software industry. In tune with these recommendations, the capacity of the higher education system in engineering in the country has been expanded besides setting up of new institutions like the National Institute of Information Technology with industry participation.

The emergence and growth of software sector in Bangalore highlights the role of human capital in a clear manner. Though the state of Karnataka has only 5 per cent of India's population it has nearly 15 per cent of its higher education enrolments. Karnataka had 83 engineering colleges under Vishweshvaraiah Technology University offering the Bachelors of Engineering degrees.5 Of these, 25 colleges were located in Bangalore; 59 are in the Bangalore region. There are eight other non-engineering universities, two of which are in Bangalore. Bangalore University itself has over 50 colleges located within Bangalore. Though not a source of engineers, these colleges contribute to English-speaking science and IT-proficient graduates (D Costa 2006). Karnataka has two of the nine national institutes of technical education including the Indian Institute of Information Technology (IIIT) and the established Indian Institute of Science (IISc), two of the 43 regional engineering colleges, 12 per cent of the country's degree colleges under universities

granting technical degrees, and 15 per cent of diploma-granting polytechnics (Okada 2004: 298).

Apart from the policy measures for the creation of IT manpower and R&D infrastructure, various other policies relating to finance, trade, investment and taxation have been initiated by the state from time to time. The importance of promoting software development had been recognized by the Department of Electronics and suitable policies and programs were put in place as far back as 1972. In a period when very high tariff and non-tariff barriers were the rule, duty free import of computer systems and without reference to indigenous angle clearance was permitted for software export. Moreover, in a period when there were series of restrictions on FDI, 100 per cent foreign owned companies were permitted to set up software export operations provided they locate in the Santacruz Electronics Export Processing Zone (Parthasarathi & Joseph 2002). Later the computer policy of 1984, software policy of 1986 and the new economic policy of 1991 had various provisions for the development and export of software. The policies initiated since 1991 explicitly aimed at opening the economy for foreign investment and export by reduced custom duties, encouragement of portfolio investment and foreign collaboration in addition to income tax exemptions and tax holidays.

Firms and other Actors

The development of the IT software sector in India has been mostly at the instance of local firms. While some of the pioneering ones like Tata Consultancy Services belonged to the large business houses, some of the most dynamic ones like Infosys belonged to entrepreneurs with prior IT experience and in 2001 they accounted for nearly 37 per cent of

the IT sales (Athreye 2005). An interesting feature of the Indian software industry is the relatively large and growing number of companies participating in the development and export activity. By 2005 according to the data published by the Software Park of India (STPI) the number of firms registered with the STPI has reached a level of over 3500. As expected, larger firms do account for a disproportionate share of revenue and exports, with the top 20 companies accounting for a 43 per cent of the total exports in 2004-05.

While India's ICT success has been by and large home grown almost all the leading foreign IT companies have their presence in India. The entry of Citicorp Overseas Software Ltd. (COSL) in Bombay in 1985 and of Texas Instruments (TI) in Bangalore in 1986 highlighted India's potential to outside MNEs. Subsequently, a number of other western corporations began to follow the footsteps of COSL and TI, such as HP in 1989 and followed by Novell, Oracle, among others. Seeing the potential, a number of Indian companies engaged in the manufacture of computer hardware started to spin-off their software divisions (Heeks, 1996, for more details). The use of satellite links for data communication by TI's development centre in Bangalore in 1987 also served to demonstrate to the government the critical importance of providing satellite data communication links for software exports from India (Kumar 2000). Hence the government started to provide the high-speed communication links in the STPs.

By 2003-04, 112 of the 572 member companies of NASSCOM were reported as foreign companies. Although many of the large MNEs have established development base in India, their overall share in India's exports of software is rather small accounting for only about

30 per cent of the total exports (NASSCOM 2006). Even in 2004-05 MNEs do not figure among the top seven software companies in India, ranked either on the basis of overall sales or the exports. Among the top twenty software companies too, no more than four are MNE affiliates or joint ventures. MNEs, however, are important clients of Indian software companies and have contributed significantly through spillovers (Patibandla and Peterson 2002).

Apart from firms, both local and foreign, the other major actors are the industry associations. While the state initiatives laid the foundation for faster growth, the industry associations[5], particularly the NASSCOM played an important role. In addition to lobbying at the Central and State governments levels, the NASSCOM also played a key role in projecting India's image in the world IT market. For example, in 1993 NASSCOM appointed a full time lobbying firm in Washington. It facilitated the participation of Indian firms in a large number of international IT exhibitions and projecting India's capabilities in the sphere of IT. Role that NASSCOM played in getting the visa rules relaxed by the developed countries, especially USA, is well known. Also, in 1994 NASSCOM initiated the anti piracy initiatives in India, when IPR was becoming a major issue in the Indo-US relations (Kumar and Joseph 2006). It took up the campaign against software piracy and conducted a number of well-publicized raids[6]. Of late, various initiatives have been made by NASSCOM to promote interaction between the industry and academia.

R&D Infrastructure and Networks

Since the early 1970s, Government has been supporting R&D for development of computer software at different institutions such as TIFR, IITs, IISc, select universities (such as Jadavpur University), ISI, and CSIR Laboratories. The Technology Development Council has been supporting R&D projects since its inception in 1973. These programmes of technology development have led to building up of capabilities and have provided experienced manpower for the rapid development of the industry. For instance, the capabilities built in the process of early work on data communication at TIFR started in the late 1970s and anchored at the DoE supported National Centre for Software Technology (NCST), set up in Bombay in 1984, proved instrumental for development of country wide networks and for internet in the country in the 1990s. The government S&T agencies have set up a parallel Super-computer Education and Research Centre (SERC) and Department of Computer Science and Automation at IISc, which provided high end expertise and manpower to the industry. Besides NCST, DoE has also set up another institution for technology development in the 1980s viz. Centre for Development of Advanced Computing (C-DAC) that developed India's first super computer – Param - and has developed software for Indian languages' script. Electronics Research and Development Centre (ER&DC) is another new R&D institution set up by DoE. ER&DC has research facilities at Thiruvanathapuram and Calcutta and has acquired another unit at Noida near Delhi. The government has also stimulated and supported R&D activity of industry through tax incentives and direct funding on a limited scale by DoE.

India's S&T infrastructure coupled with the relative abundance of qualified but cheap R&D manpower has begun attract MNEs to India for setting up global or home-base augmenting R&D centers. In the past five years, over 100 MNEs have set up R&D centers in India. These include GE's $80 million technology center at Bangalore that is the largest outside the US employing more than 1600 people. A study by TIFAC (2004) on FDI in India's R&D sector during 1998-03 has shown that as many as 400 top US companies have set up R&D centers in India. Further, R&D investment worth of $1.13 billion has flowed into India during the five year period 1998-2003 leading to exports worth 2.3 billion in 2003-04. Indian R&D centres of the US MNEs have filed more than 1000 patent applications with the US PTO mostly during 2002 and 2003

Detailed systematic empirical studies on the interaction between the academia in general and R&D centers in particular with the industry are yet to be undertaken. Castells (2000) argued that Bangalore, the IT capital of India, cannot be viewed as an innovative region because of the lack of technical expertise, technical community with a deep and diverse range of capabilities, and minimal interactions among local firms (see also D Costa 2006). In a context of limited industry university interaction that in turn leads to the mismatch between the skill set possessed by the candidates and needed by the firms, some of the large companies have to make considerable investment in in-house training.

TCS, the first entrant to the software sector in 1969 and the largest firm at present spends nearly 10 per cent of the sales on in-house training (Patibandla et al 2000). The same is the case with other large firms like Infosys, Wipro and others. In fact the training infrastructure of some of these companies are on a larger scale than some of the leading universities[7]. But

there are studies indicating an increasing interaction between leading institutes like Indian Institute of Science, Bangalore and different IITs (Basant 2003, Chandra and Krishna 2006). Also, enhanced interaction between industry and academia is one of the top agendas NASSCOM as is evident from the memorandum of understanding between NASSCOM and UGC to develop industry oriented manpower resources and the series of industry academia sessions organized by it (NASSCOM 2006). Apart from the increasing participation of Indian forms in Global R&D networks that we have noted earlier, if the recent field level evidence provided by Parthasarathy and Aoyama (2006) is any indication, there is increasing incidence of collaboration and networking among Indian firms, as they seek to diversify their client base and business opportunities by entering into global production network for embedded system design, IP block development, R&D and other related activities. In the case of Bangalore, its initial advantage as the location of government laboratories and military research, combined with the presence of major MNCs, as argued by Parthasarathy and Aoyama provided the foundation for institutional thickness emerging around its software industry and facilitated technological upgrading.

7.3.2. Dynamics of India's ICT sectoral system of innovation

The recent evolution of the ICT sectoral system of innovation in India can be characterised by six major transformation processes: the gradual move of Indian ICT firms into more knowledge intensive activities in the global value chain, the widening of domain expertise and application, the growing specialization in software products, the accumulation of capabilities and the subsequent increase in the number of accredited firms, the shift from

onsite to offshore and the emergence of IT multinationals from India. Next we will discuss each of this changes in details.

Moving up the Value Chain

The comparative advantage of Indian firms has been in the export of services such as customized software development. Indian firms have been operating mostly at the lower end of value chain by carrying out low-level design, coding and maintenance. As a result, revenue per employee in 1999 is found to be only about one-tenth of Israel and one-fourth of Ireland (Arora et al 2001). Moreover, the net export earning has been only of the order of 50 per cent of the gross FOB value of total exports of software and services (Joseph and Harilal 2001). However, of late there are number of indications to show that the trend is changing on account of increased learning and domain expertise in a number of areas. With the MNCs increasingly looking for complementary capabilities, Indian firms are getting engaged in highly skill intensive areas like chip design and R&D and thus are moving up the value chain marked by a shift away from Business Process Outsourcing to Knowledge Process Outsourcing (Parthsarathy 2006). Now the firms are increasingly entering into high end consulting, engineering services with the development of domain expertise. As a result the revenue per employee has recorded a six-fold increase from about $6200 in 1993 to $35,129 in 2000 (Athreye 2005) and the trend continues.

Since the conventional measures of innovation like R&D intensity (measured as Research expenditure as proportion of sales) has certain limits in capturing innovation in a service

sector like ICT, a study by Joseph and Abraham (2005) developed an Index of Claimed Technological Competence (ICTC) using firm level information on their areas of specialization. The theoretical base of the index has been drawn from the literature on technological opportunity. The estimated index revealed an upward mobility of firms. To illustrate, in 1998 over 56 per cent of firms were in the low index category (less than 30%) where as in a short span of three years the share of such firms declined to around 44 per cent. Similarly in the higher index category (greater than 60%) the share of firms increased from 5.3 per cent in 1998 to 8.3 per cent. in 2001. The estimated index of leading IT firms like Infosys, Wipro, TCS and Satyam were found to be more than 75 per cent. Thus, notwithstanding any significant increase in the R&D intensity of firms there appears to have been an upward mobility of firms in terms of the estimated ICTC.

Widening domain expertise and applications

There are also indications to show that the Indian companies have developed domain expertise in a wide range of domains and industries. Banking, insurance and finance has emerged as areas in which they have developed particular expertise and have even launched packaged software. An evidence of the growing ability and expertise of Indian software companies was provided by their ability to manage transition from Y2K-related projects successfully. In 1998-99, 16.5 per cent of the export earnings of Indian companies were derived from Y2K related projects[8]. Over 1996-99, Indian companies are reported to have earned $2.5 billion from Y2K projects (Nasscom, 2000). Hence, it was widely expected that the loss of these projects with the turn of the century would lead to a decline in the

growth rates of exports. However, the Y2K transition has been managed successfully on account of ability to quickly diversify into Internet and e-commerce related technologies and applications leading to a sustained increase in exports (see table 7.1).

Table 7.1: Areas of Expertise Claimed by Indian Software Firms: 2001-2002

Areas of Specialization	Number firms reporting Competence in	Percent
Antivirus/Security solutions	82	13
Application	161	25.5
Business Processing consultancy/Reengineering	261	41.3
CAD/CAM/CAE	71	11.2
Call centers	114	18
CD-Rom publishing/Multimedia	86	13.6
Chip design/Microprocessor/ASIC	49	7.8
Computer Games/Computer Graphics/Animation	85	13.4
Data Processing/Data conversion	158	25
E-commerce/EDI/CRM solutions	423	66.9
ERP/MRP solutions	223	35.3
GIS/Imaging	91	14.4
ISPs/Payment Gateways	72	11.4
IT education& training	152	24.1

Localization of Software	134	21.2
Medical Transcription	27	4.3
Product distribution/Support/Implementation	188	29.7
RDBMS/Data warehousing/Data mining	345	54.6
Software maintenance and migration	345	54.6
Software Product Development	420	66.5
System integration/networking	312	49.4
Telecom solutions/Communications software	191	30.2
WAP/M-commerce	211	33.4
Web content development	229	36.2
Web technology/internet/intranet	474	75
Total number of firms	630	

Source: Joseph and Abraham (2005)

Note: Percent will not add up to 100 because the firms engage in more than one activity.

Increase specialization in software products: Table 7.2 provides an indicative list of firms with presence in software products. Though indicative, it is evident from the Table that a number of Indian companies have managed to enter into the area of software development. For most of these firms, domestic sales account for substantial part of their revenue. A niche market has been created in banking, financial and accounting software. These include, for instance, I-Flex that has been used by over 240 financial institutions in 69 countries. Banking solutions from Infosys (Financle, Bankaway, and Payaway) have been adopted by 22 domestic and 16 overseas banks across 12 countries as early as in 2001. TCS

launched packaged software for banking insurance, securities, accounting, and health care industries. TCS also launched its branded integrated suite of software tools Mastercraft which is claimed to have been received well in the US and Europe and carries a price tag of US $ 150,000.

Table 7.2 Profile of Select Software Product Firms (2002-03)

Name of the Firms	Major Products	Revenue from Product Sales in (Rs Million)	Product Sales as a % of Total sales	Domestic Sales as a % of Product Sales
i-Flex	FLEXCUBE-caters to both corporate and retail banking	3000	64	5
Infosys	FINACLE Core Banking	1810	5	47
	FINACLE eChannels			
	FINACLE CRM			
	FINACLE eCorporate			
	FINACLE Treasury			
Tally	Business accounting software-TALLY ees 6.3	NA	100	94
TCS	Products for financial banking, manufacturing and health sectors	660	7	NA
Polaris(Erstwhile	BANKWARE, ORBI suite of			

Orbitech)	financial products	600	16.4	90
Newgen	OminFlow, OmniDocs, OmniExtract, OmniCapture, OmniReports	245	76	47
Kale	Cargo Solutions, Business Intelligence Software, Passenger Solutions	85	NA	30
ESS	Makess ERP, ebizframe	70	NA	NA
Ramco	Ramco e-applications, Ramco VirtualWorks	>500	67	NA
Aditi Technologies	Talisma -eCRM product	>500	NA	NA
Subex	Telecom sector – RevMax	2550	36	8.1

WIPRO Technologies launched a number of branded products including Teleprodigy, a billing system for ISPs, and WebSecure, an Internet security package. It is focusing on global brand building and plans to come up with a branded product every year. A number of even smaller software companies have developed packaged software, which is sold in domestic market. For example, Tally, a popular accounting package for small and medium enterprises which is being used by 50,000 companies and has been approved by the Accountants' professional bodies in India and the UK has been developed by a smaller highly specialized software company (Kumar, 2001)[9].

Accumulation of capabilities - International Quality Accreditation

International orientation and the increasing professionalism of Indian software enterprises has prompted them to align their processes with global best practices and to obtain international certifications. In 2005-06 among the 401 firms that reported different international quality standards 82 had SEI CMM level 5, the highest level of quality accreditation across the globe, which that accounted for more than two-thirds of such firms in the world over. As many as 123 firms had SEI CMM level 2 certification or above and 330 had ISO 9001 (NASSCOM, 2006). If the evidence is any indication most of the Indian software enterprises have strived to attain excellence in their professionalism and best practices.

Shift from Onsite to Offshore

During the early years of its development, the software and service exports from the country was carried out mostly in the form of onsite development (Heeks 1996). With the setting up of a number of Software Technology Parks, which inter alia provided access to modern telecommunication facilities, and liberalized policies towards the telecom sector, which in turn led to the entry of a number private sector telecom companies, there has been a significant shift away from onsite development. By 2005-06 nearly 70 per cent of the exports take the form of offshore development (see Figure 7.2)

[Fig. 7.2. about here]

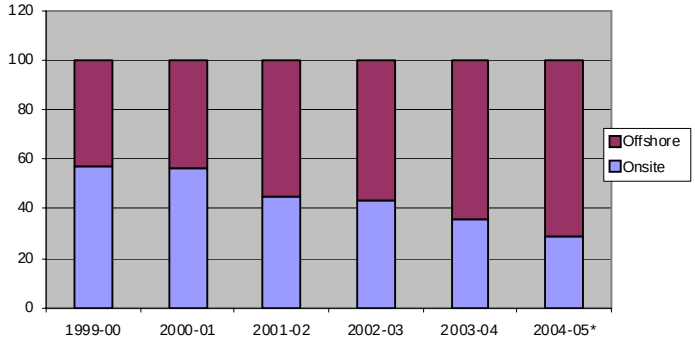

Fig 7.2 Changing Share of Onsite and Offshore Services

Emergence of IT Multinationals from India

Indian companies are enhancing their innovative capabilities and competitiveness through a combination of green field initiatives, cross border mergers and acquisitions and global partnerships with foreign forms. These initiatives are expected to bring complementary capabilities required by the Indian firms. (see Box 7.2 for an indicative list). Prior to 1992, the Indian policy towards Outward Foreign Direct investment (O-FDI) was restrictive. The policy allowed only joint ventures with minority participation, which should be made by capitalization of the exports of the indigenous plant, machinery, capital goods, and know-how rather than cash remittances.

BOX 7.2 Highlights of Green-field Initiatives, Cross Border M&A, Global Partnership and Alliance undertaken by India´s IT Firms (2005-06)

- Tata Consultancy Services acquired a 100 per cent equity stake in Chilean BPO firm Comicrom for USD 23 million; acquired Australian banking software vendor Financial Net services Pty Ltd: bought out the life and pensions business processing division of UK- based Pearl Group; entered into partnership with SAP AG to jointly offer solutions and services to the manufacturing vertical and became a global strategic SI partner of salesforce.com AppExchange.TCS also entered into a three way joint venture with the Chinese Government and Microsoft to build presence in China.
- Infosys Technologies announced a USD 65 million investment to set up two new software development centres in China, over the next five years.
- Wipro acquired Austria based semiconductor design services firm NewLogic in an all-cash deal valued at USD 56 million; also acquired mPower Software Services Inc., an IT service company in Princeton, New jersey, and its development centre in Chennai, India.
- Sathyam Computer Services acquired Citisoft, a specialist business and systems consulting firm for the investment management community for USD 23.2 million, with an additional performance based payment of up to USD 15.5 million to be paid over three years.

- HCL entered into a strategic outsourcing agreement with EXA,a Japanese systems integration services provider and announced the setting up of a new facility for its joint venture with NEC,NEC HCL Systems.
- vCustomer Corporation acquired eight call centres of global telecom giant MCI (seven call centres in US and one in Philippines)
- WNS Global services acquired Trinity Partners, a US based company, to strengthen its presence in the mortgage and financial services business.
- Office Tiger acquired Mortgage Ramp, a unit based in Utah, US.
- Genpact acquired Creditek, a New Jersey-based order-to-cash and receivables management company with particular strength in the healthcare industry.
- Mphasis acquired Eldorado Consulting.
- ICICI OneSource acquired RevIT to strengthen its healthcare, printing and publishing process capabilities.
- Zensar Technologies Limited acquired a US-based SAP services provider OBT Global Inc and its offshore affiliate OBT Global Pvt Ltd India.
- Cognizant Technology Services forayed into the BPO space through a multi-year relationship with Pfizer Global Research and Development to provide clinical data management and biometrics services.
- Covansys acquired a 70 per cent stake in Fortune Infotech Limited, an India- based BPO.
- Sutherland Global Services entered into a marketing alliance with Talisma, a provider of online customer service and support market software. The partnership

expands the market reach for Talisma's multi-channel customer relationship management solutions and provides Sutherland clients access to Talisma's technology solutions.

- Cybernet Software Systems group company Slashsupport, which has four offshore facilities in Chennai and a redundancy centre in Singapore, announced plans to set up a new facility in US to meet some of the domestic requirements there.
- Publishing group Infomedia India acquired UK-based Keyword Group and the Indian firm Cepha Imaging Systems.
- Cambridge Integrated Services, a subsidiary of Scandent Solutions, an Indian IT outsourcing provider, entered into a knowledge partnership with Scope International, a subsidiary of Standard Chartered Bank providing BPO services in the banking domain.

Source: Strategic Review 2006 The IT Industry in India , NASSCOM

In October 1992, the policy regime was liberalized with the issue of the modified guidelines for Indian Joint Ventures and wholly owned subsidiaries abroad. This allowed for automatic approval of O-FDI and more liberal cap on Indian equity participation. By 2004, the cap on equity participation in O-FDI was removed and was limited by only the net worth of the investing Indian company. The sectoral composition of overseas M&As by Indian firms reveals that services sector, mostly led by the software, accounted for the highest share of acquisitions made. Of the 119 M&As during the four year period 2000 to 2003 more than 56 percent (67 M&As) were undertaken by the software firms (see Table.

7.3). Most of this M&As were in the developed economies of UK and US. Studies show that most of these M&As are aimed at getting access to the new markets and other complimentary assets[10].

Table 7.3: Sectoral distribution of the number of M&As in Indian Companies

	2000	2001	2002	2003	Total	
					2000-03	Percent
Primary		2	2	5	9	7.6
Industry	7	3	9	15	34	28.6
Services of which:	28	18	10	20	76	63.9
Software	23	17	9	18	67	56.3
Total	35	23	21	40	119	100

Source: Pradhan and Abraham (2005)

7.4. Concluding observations

While foregoing discussion highlighted the building blocs and dynamics of the sectoral system in India's ICT sector, it is also important to note that there are certain aspects of its

transformation that could be attributed to the specifics of the innovation system in the South. The dynamics of the sector was governed to a great extent by the export demand though the software policy of 1986 underlined the importance of an integrated development of software for the domestic and export markets (Government of India 1986). The export driven growth model, to a great extent, influenced the nature of India's software and service sector in the country. While India is endowed with an abundant supply of highly skilled manpower, India is yet to be known as a major player in skill intensive areas like software products. Going by the available data, the share of software products in total exports declined from 11 per cent in 1996 to three per cent 2003 (Parthasarathy 2006). What is more, bulk of the sales by firms focusing on software products came from the domestic market. Institutional arrangements are yet to be evolved either towards promoting domestic market or for promoting inter-firm collaboration in developing products. More over, there has been an increasing regional concentration in exports wherein nearly 68 per cent of the total has been directed towards the US market (Joseph and Parayil 2006, Chandrasekhar 2006). It has also been shown that the software export boon had its adverse effect on those sectors competing for skilled manpower on account of the resource movement effect (Joseph and Harilal 2001, Joseph 2006a). Thus India is having a booming software sector while the hardware sector lags much behind.

The ICT diffusion, it has been shown, could be instrumental in enhancing efficiency and productivity in the using sectors. But the ICT sector is yet to be embedded with the local production system and this is a dark side of India's ICT success because one of the central sources for industrial development and innovation is the embeddedness of firms in the local

production system (Parthasarathy 2000). A recent study has shown that the IT investment intensity (measured as IT investment as a share of total investment) in India's manufacturing sector has been rather low - on the average, less than one percent of the total investment. Even in some of the sectors that are considered IT intensive in the developed economies, such as printing and publishing, manufacture of motor vehicles and manufacture of precision equipments the IT intensity hovered around one percent. Overall, the IT intensity in investment gives the picture of the nascent stage of IT adoption and diffusion in the Indian manufacturing sector (Joseph and Abraham 2007).

To the extent that the less developed countries have a number of information needs that could be met by using IT, they could benefit from increased access to information as much as the rich countries. No wonder, there is hardly any developing country that has not undertaken policy measures and institutional interventions to develop IT capabilities and harness the new technology as a short cut to prosperity. In India there are numerous projects undertaken at the instance of different stakeholders to harness ICT for addressing poverty and other development goals (India, Planning Commission 2001, Kaushik and Singh 2004) in addition to various e-governance projects initiated by the government. Thus, today there are different stakeholders- central and state governments, civil society organizations and the private corporate sector – involved in harnessing for addressing various developmental issues in India. While the large number of IT initiatives have created an impression that India is well on the path to harnessing ICT for development, in reality, they have been sporadic, involving the process of learning by doing, very often than not, lacked strategic sense and a national perspective and resulting in duplication of

efforts[11]. On the whole, it appears that while India is known as a major producer of ICT her progress in ICT use so far has not been remarkable and seems to have not effectively articulated the social marginal product of a dollar worth of ICT used at home as compared to a dollar worth of ICT exported (Joseph, 2002).

However, the experience of India in the ICT sector is a clear indication of the possibility of developing countries to participate successfully in the international division of labour in knowledge intensive sectors. While the performance with respect to the diffusion of ICT into different sectors of the economy for harnessing it for enhancing productivity and competitiveness has not been remarkable in the context of excessive export orientation, its contribution towards exports, employment and GDP has been exemplary. The observed record, despite the challenges under the new environment, has been made possible because India's globalization policies, indeed at her own terms and at her own pace, was preceded by some effort towards evolving the key elements of the sectoral system. These measures have had the effect of providing an abundant supply of skilled manpower and the institutional infrastructure for sustaining exports of software services and later diversifying into IT enabled services. The diversification into ITES, though indicative of the downward movement along the value chain has had the effect of promoting broad-based development in the country. The sectoral innovation system in the ICT sector led by local firms with active participation by foreign firms, network of R&D institutions and firms in a conducive policy environment, seems to have facilitated an upward movement along the value chain. This is evident from the country's increasing participation in the global division of labour in R&D, embedded software development and other high value adding activities. To

conclude, the new challenges notwithstanding, the developing countries could profitably engage in knowledge intensive sectors like ICT, if they invest substantially in evolving institutional arrangements at the sectoral level for learning, both tacit and codified knowledge, and innovation driven partnership wherein trade and investment serves as a means and not an end.

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NOTES

[1] For example, in France sectors related to public demand have grown considerably (Chesnais in Nelson, 1993). In other cases, national institutions may constrain the development or innovation in specific sectors, or mismatches between national and sectoral institutions and agents may take place.

[2] The case of lagging hardware sector in India in a context of booming software is an example. For details see Joseph (2007).

[3] This includes domestic software and as noted by Desai there are problems in estimating value and employment generated in domestically consumed software (see for details Desai A V, Business Standard, 8 July 2002).

[4] *Dataquest*, 31 May 2000, 15 June 2000.

[5] To begin with, there was the Computer Society of India, which is essentially an association of academics and professionals and did not address many of the issues faced by the industry. Hence a new association called Manufacturers Association of Information Technology (MAIT) was formed in 1982. This consisted both the hardware and software firms. Later an association, currently known as Nasscom, was formed to address specific issues being faced by the software and service companies. The Electronics and Software Export Promotion Council, an autonomous body under the MIT, though its various, initiatives also made significant contribution towards India's IT export growth.

[6] For a detailed account of the Nasscom activities in promoting IT, see " Power Lobbying", *Business India*, February 19 to March 4, 2001.

[7] See for details, Infosys builds world's biggest training center in Mysore. http://www.mysoresamachar.com/info_trg_cent.htm.

[8] See *Dataquest*, 15 July 2000.

[9] For detailed discussion on Software product Development experience in India see Krishnan and Prabhu 2004).

[10] Pradhan and Abraham (2005) pp 378-379.

[11] For a critical analysis of various ICT project in India see Sreekumar (2006).