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Growth of ICT and ICT for Development

Realities of the Myths of the Indian Experience

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Abstract

While there is an increasing realization of the potential that IT offers for human welfare, IT-induced productivity and growth are confined to the developed world. It is argued that even though the international digital divide is a reality, there are certain specific characteristics of the new technology that leave scope for mitigating, if not totally bridging, the gap when appropriate policies are in place. During the last decade India has attempted to profit from the growth of ICT through export-oriented growth strategy, and the issue of ICT in development has not received the attention it deserves. The paper highlights the perils of the strategy followed by India and underlines the need to focus on development through ICT. The study shows that the unprecedented export performance of India's software has to be seen in the context of the national system of innovation that evolved during the last five decades when the state played a proactive role. Also, the country's high export growth cannot be attributed entirely to the market-oriented policies of the 1990s. Higher growth rates in exports notwithstanding, it is shown that net export earnings have been much lower. While the low net export

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earnings reduced the possibility of real appreciation, the boom in the IT sector is likely to have had an adverse influence, at least in the short run, on other sectors competing for skilled manpower because of the resource movement effect. Thus while an IT-induced development strategy could have been instrumental in enhancing efficiency, competitiveness and growth, export-oriented IT growth strategy seems to have enabled other countries to become more efficient and competitive. The export-oriented growth strategy also had an adverse effect on the innovative performance of firms. The findings of the paper tend to underscore the need to recognize the complementary role of the domestic market in promoting innovation and exports on the one hand and IT-induced productivity, competitiveness and growth on the other. Hence there is need for a policy that focuses on ICT for development. This in turn calls for comprehending the social marginal product of a dollar worth of IT exports vis-à-vis its domestic consumption.

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1 Introduction and background

Today, we are living in a world where information communication technology (ICT)[1] is being diffused into almost all spheres of human activity at an unprecedented rate. Side by side with this development, there is also an intense debate on the contribution of this technology towards productivity and growth on the one hand and human welfare on the other in both developed and developing countries. By juxtaposing the slowdown in productivity growth in the US since the late 1960 against the dramatic increase in IT spending over the same period, studies have come up with the 'productivity paradox', arguing that IT has not resulted in expected productivity improvements (Roah 1987; 1988) Strassman (1997). If evidence from recent cross-country studies is any indication, returns to investments in information technology in terms of productivity and growth are substantial (Pohjola 2001; Kraemer and Dedrick 2001). Pohjola finds the output elasticity of IT capital to be as high as 0.31 for a full sample of 39 countries and 0.23 in an OECD subsample. Another cross-country study by IMF (2001) also has similar conclusions to offer. Country-specific studies like the one for Singapore (Wong 2001) find that the net return to IT capital (37.9 per cent) is about two and a half times higher than that for non-IT capital (14.6 per cent). These studies also show that IT induced productivity and growth still remain a phenomenon of the developed (OECD) countries and that the developing countries are yet to catch up.

This takes us to the other dimension of the ongoing debate—the international digital divide. Given the present unequal access to ICT, it has been argued that new technology reinforces disparities between postindustrial societies at the core of the network and developing countries in the periphery. Multilateral organizations like OECD and UNDP share the same view. OECD (2000) states that affluent states at the cutting edge of technological change have reinforced their lead in the new knowledge economy, but so far benefits have not yet trickled down to Southern, Central and Eastern Europe, let alone to the poorest areas in the Sub-Saharan Africa, Latin America or South East Asia. In a similar vain, UNDP (1999) argues that productivity gains from information technology may widen the gulf between the most affluent nations and those that lack the skills, resources and infrastructure to invest in information technology. Hence, any discussion on ICT induced development has to begin with the question: unlike earlier technologies, are there any unique characteristics of the new technology that make it possible to mitigate the international digital divide, if not bridge it altogether?

Analytically, the contribution of ICT can be viewed at two different but interrelated levels—ICT growth and ICT diffusion. The former refers to the contribution in output, employment, export earning, etc., resulting from the production of ICT related goods[2] and services that are limited to just one segment of the economy (Kraemer and Dedrick 2001). The latter refers to IT induced development through enhanced productivity, competitiveness, growth and human welfare resulting from the use of this technology by different sectors of the economy and society. India has mainly attempted to profit from ICT growth through a series of institutional innovations and export oriented policy

1 In this paper I use the terms ICT and IT interchangeably.

2 Such benefits are not confined to the developed countries alone. A classic example is India, which has emerged as a major player in the ICT trade in recent years.

measures,[3] based on the implicit assumption that market-oriented ICT growth strategy will also result in the diffusion of new technology and ICT induced development. Hence, the often-claimed achievements with respect to India's ICT have not been in terms of harnessing new technology for enhanced efficiency and productivity growth, but instead for promoting export earnings for the economy. Indeed, India's export performance has been unique in comparison to other export products, not only in terms of growth rates but also in terms of its stability. Hence, the question to be addressed in the context of countries like India is, whether if left to itself, would the development of ICT result in IT induced progress and human welfare?

Governmental task forces[4] and the academia on the one hand and journalists on the other have contributed to a burgeoning literature on the different aspects of ICT in India. However, most of these studies have focused on the direct benefits of ICT growth, and the issue of IT in development has not received the attention it deserves. The unavoidable outcome has been the proliferation of a number of assertions regarding the benefits of IT growth to the economy. These *prima facie* appear convincing but an in-depth analysis with supporting data suggests that the IT scene in the country is burdened with a number of myths. The purpose of this paper is to highlight the realities of some of these myths and clear the debris, at least partly, so as to make development through ICT the focus of research and policymaking in India. We propose to undertake this against a critical analysis of the empirical basis of the arguments regarding international digital divide.

The myths, arising from the often followed practice of substituting casual observation for rigorous analysis, range from the role of state in the sector's growth performance to its growth dynamics *per se*, as well as its implications on the rest of the economy. Thus, it has been argued that India's growth ICT dynamism has been the result of a benign neglect of the sector by the state (Kattuman and Iyer 2001; Arora *et al.* 2002). Let us call this the 'myth of benign state neglect'. Second, and related to the policy myth is the often-made claim that growth performance of this sector under the globalization-liberalization period has been unprecedented. This could be labelled as the 'myth of liberalism induced growth'. Third, we undertake critical analysis of the direct contribution of ICT to export earnings, and reflect on the implications of the IT boom on the rest of the economy. Finally, it has been argued that an export-oriented policy regime is more conducive to attaining technological dynamism and growth. Hence, the developing countries in general have been swinging between import substitution and the free trade fever. In this context, I intent to test this hypothesis with respect to the innovative behaviour of Indian IT firms. The central message of the paper is that instead of focusing on ICT growth, it is high time for India to shift its focus towards ICT induced development. In what follows next, I take up each of these issues and subject them to analytical and empirical scrutiny within the limits of data availability.

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3 This is not to argue that the importance of ICT diffusion has not been recognized. For example the software policy of 1986 explicitly recognized importance of balanced (software for export and domestic use) development of software. Similarly, the IT taskforce also underlined the need for citizen interface and e-governance. However, the explicit policy measures were mainly aimed at developing an IT base for export.

4 Here the reference is to the national taskforce on information technology and software development, taskforce on human resource development for IT and the taskforce on knowledge society.

2 Digital divide: An unbridgeable divide?

Notwithstanding the current unequal access to IT, it has been argued that in the current era of globalization the ability to harness technology improves the capability of developing country-firms to withstand competition from multinational corporations or to develop partnership with them. At the same time, IT poses a potential threat. If the developing countries are unable to harness this new source of wealth, they will fall even further behind (Pohjola 1998). Moreover, developing countries are expected to gain substantially through ICT spillovers (Mohnen 2001). Drawing on the new growth theories, it may be argued that ICT could be instrumental in breaking the vicious circle of idea gap and object gap (Romer 1993)—the rootcause of persistent poverty and underdevelopment. No wonder developing countries have shown great interest and pegged high hopes on information technology as the shortcut to prosperity (UNDP 1999; World Bank 1999).

But given the current state of ICT access wherein half a billion people in Sub-Saharan Africa share 14 million telephone lines—which is fewer than in Manhattan or in Tokyo—and almost half of the world population have never made a telephone call, how realistic are the claims made above? What is more, studies have shown that inter-country differences in the rate of IT diffusion are significantly related to the general level of socioeconomic development (per capita GDP, R&D expenditure and levels of human development) (Hargittai 1999; Rodriguez and Wilson 2000). These results tend to indicate that to achieve IT induced development, developing countries will have to wait until they cross the hub of per capita income growth and human development. Thus viewed, developing countries are trapped in the vicious circle of low per capita income that leads to a low level of IT diffusion, resulting in turn in low per capita income and growth.

Such a pessimistic view has been further articulated by Norris (2001). In her analysis of the correlation between levels of diffusion of old media (television, radios, telephones, newspapers) and new media (PCs, internet, etc.) across different countries, she found a highly positive and statistically significant relationship (see Table 1).

Based on this finding, it was concluded that there was little distinction between old and new media, and the proportion of those online in each country was most strongly related to the distribution of hosts, telephones and PCs, but was also significantly and strongly related to the distribution of radios, TV sets and newspaper readership in each country.[5] These studies, therefore, suggest that 'to them that hath, shall be given'.

In reaching such pessimistic conclusions, the studies cited above seem to have failed to recognize certain unique characteristics of the new technology which do not make the leapfrogging impossible as long as appropriate policies are in place. To begin with, unlike earlier technologies, investment in new technology essentially complements investments already made in communications technologies, like satellites, telephone networks and cable TV networks. Thus there can be substantial returns with marginal investments. Second, newly developed technology like the 'wireless in local loop' (WILL) by the Indian Institute of Technology, Chennai, makes it possible to connect remote villages and thus greatly reduce the cost of last mile connectivity (Planning

5 It was also noted that there are a few outliers that may have significant implications for policy initiatives designed to broaden the spread of the wired world (Norris 2001: 54).

Commission 2001). Third, new technology is multi-user by nature which, in turn, leaves scope for internet kiosks, internet cafes and community internet centres, providing access to many. What is more, with the Moore's Law[6] in operation, real investment requirements in new technology decline over time. Finally, in developing countries like India that are late entrants, investments have not been tied up in old technologies and these countries, therefore, take advantage of frontline technology and cost-effective infrastructure (Planning Commission 2001). Thus, despite the efforts needed to attract new investment in ICT infrastructure and to encourage ICT usage in ways appropriate in the developing country contexts, real opportunities exist for promoting ICT diffusion through the involvement of public and private sector organizations, NGOs and other stakeholders (Mansell 1999).

There are also certain empirical problems in the studies presented above. The correlation analysis outlined above, which uses cross-section data for different countries, essentially presents a static analysis, whereas the diffusion of technology is a dynamic process, which has to be analysed in a dynamic perspective. Moreover, the technologies considered in the analysis vary in terms of their age. For example in the US, Internet is a post-1994 phenomenon, whereas television was introduced more than 50 years ago. Therefore, the present level of TV diffusion (844 sets per 1000 inhabitants) has been achieved over a period of more than five decades, while the current level of Internet diffusion (266 per 1000 inhabitants) has been reached in just over 8 years. Correlation analysis implicitly assumes that the different technologies under comparison essentially have the same characteristics. Literature shows that the diffusion of any technology is conditioned not only by the characteristics and strategies adopted by diffusion agents (Brown 1981), but also by factors specific to technology. Thus viewed, the rate of IT diffusion is governed by diffusion agents such as Internet service providers, government, non-governmental organizations and other stakeholders. While a detailed analysis which includes all these aspects is beyond the scope of this paper, I shall present a preliminary analysis by looking at the rate of diffusion rather than the level of diffusion.

Table 1
Correlations in use of the new and old media

	Online	Hosts	PCs	Radio	TVs	Newspapers	Phones	Mobile phones
Hosts	0.854							
PCs	0.806	0.745						
Radio	0.788	0.708	0.818					
TVs	0.692	0.614	0.769	0.848				
Newspapers	0.725	0.715	0.788	0.749	0.734			
Phones	0.791	0.710	0.886	0.837	0.861	0.839		
Mobile phones	0.809	0.827	0.845	0.754	0.715	0.830	0.872	

Source: Norris (2001).

6 In the 1960s Intel's founder, Gordon Moore, predicted that, for the foreseeable future, chip density, and hence the computing power, would double every eighteen months while cost would remain constant.

Table 2
Correlation coefficient between the rate of diffusion of different technologies:
Entire sample

	Television	Radio	Internet	PCs
Television	1			
Radio	0.694	1		
Internet	0.561	0.618	1	
PCs	0.568	0.639	0.913	1

Table 3
Correlation coefficient between the rate of diffusion of different technologies:
Developed countries

	Television	Radio	Internet	PCs
Television	1			
Radio	0.787	1		
Internet	0.689	0.698	1	
PCs	0.711	0.763	0.872	1

Table 4
Correlation coefficient between the rate of diffusion of different technologies:
Developing countries

	Television	Radio	Internet	PCs
Television	1			
Radio	0.577	1		
Internet	0.372	0.340	1	
PCs	0.319	0.418	0.0672	1

I have made use of the cross-section data for different countries obtained from ITU and the World Bank, and have focused on the rate of diffusion. In the absence of time-series data, I have estimated a proxy measure of the rate of diffusion (present level of diffusion divided by the number of years taken).[7] The estimated correlation coefficients between the rate of diffusion across different technologies for the entire sample, for developed countries, and for less developed countries are presented in Tables 2, 3 and 4.

It is evident from Tables 2 and 3 that the value of the correlation coefficient based on the rate of diffusion is much lower than the correlation coefficient between the levels of diffusion. More important, the value of the correlation coefficient declined substantially in the case of the developing countries. What does this finding signify? While I have not been able to fully comprehend the implications, some tentative inferences may be in order.

7 A major problem with such a measure of the diffusion rate is the assumption that diffusion takes a linear path, whereas the diffusion of technologies generally takes the form of a logistic curve.

Unlike old technologies which are more demand-driven, new technology is more supply-driven and leaves greater scope for the diffusion agents (non-governmental organizations, government, private sector and other actors) to influence the diffusion process. Hence, even with low connectivity, innovations like kiosks, cafes and community centres focussing on Internet can greatly offset the limits imposed by lower connectivity and poor information infrastructure. There are a number of organizations in the developing countries that are involved in one or more aspects of ICT development and use. The multi-institutional stakeholder networks, involving public and private sector and private sector organizations, NGOs and other stakeholders as argued by Mansell (1999) must be instrumental in the diffusion of ICTs in developing countries.

In the case of India, lately there have been a number of initiatives by the central and state governments along with NGOs and private sector to help the diffusion of ICT to different economic sectors (see Appendix). Such initiatives have been unprecedented not only in terms of scale but also with regard to new organizational innovations. While most are in their initial stage, available evidence suggests that ICT could effectively be used to transform rural regions even in a developing country like India.

Using a desk-based research method, Miller and Mansell (1999) have also documented a number of cases of ICT use in different business applications in micro and small enterprises, education and library information services and environmental/geographical information systems in India, Jamaica and South Africa. The cases illustrate applications of ICT specifically intended for use either by users in disadvantaged communities or for use by intermediaries who are closely involved in networks of social relationships that enable their use of applications to provide benefits to users.

Until today, there has been no specific policy in India's industrial sector to address the issue of IT diffusion. Nonetheless, available evidence suggests that a significant beginning has been made. Computers for accounting and management are becoming widespread, with office computers available in more than 34 per cent of the factories (see Table 5). With regard to Internet, some export-oriented industries (textiles, or knowledge-intensive industries such scientific instruments) are ahead of other industries. Evidence suggests that Indian firms, in the current era of globalization, are harnessing new technology in order to enhance their productivity and competitiveness. Thus, even though ICT for development is a lower priority, it is obvious that new technology is being diffused into different sectors of the economy. But what are the returns to such investments? How to account for the inter-firm and inter-industry variation in the levels of ICT usage? What are the constraints, and what policy initiatives are called for in order to accelerate the diffusion process? These are some of the issues on which our understanding is rudimentary and further research is required in order to make informed policy decisions.

Against this background, we now examine the processes and outcomes of export-oriented growth strategy for IT. Since the growth of IT sector, particularly software, has been subjected to a number of detailed enquiries,[8] I will highlight the realities of some of the myths, and analyse some of the implications of export-oriented IT growth.

8 For example, Heeks (1996); Kumar (2001a); Joseph and Harilal (2001); Arora *et al*. (2002); Nath and Hazra (2002).

Table 5
Indicators of IT use in India's industrial sector (1997)

Industries (2 digit level)	Total no. of factories	Per cent of factories with: Computers in the office	Network	Internet	Robots or computer in production
Food products	14,695	13.01	0.84	1.39	0.29
Other food products	8,109	24.17	1.38	2.01	1.64
Beverages tobacco, etc.	8,669	47.81	0.36	0.28	0.14
Cotton textiles	9,227	22.28	0.54	1.87	1.37
Wool/silk manufacture of textiles	3,989	49.76	1.25	2.28	0.25
Jute & other vegetable fibre textiles	503	16.70	0.40	3.78	0.60
Textiles prod., incl. apparel	5,409	51.32	3.18	11.31	2.09
Wood and wood products	3,787	8.98	0.40	0.95	0.24
Paper and paper products	6,304	38.50	1.84	3.73	4.71
Leather products	1,742	37.60	1.89	7.18	0.29
Basic chemicals and related products	9,357	50.69	2.91	5.58	2.56
Rubber plastic and coal	7,597	42.57	2.80	4.01	1.59
Non-met. mineral products	11,376	13.37	0.41	0.95	1.09
Basic metal and alloys	6,915	41.94	0.93	3.69	1.72
Metal products	8,243	31.68	0.92	2.86	1.01
Machinery and equipment	8,203	44.46	2.12	5.63	2.66
Electric machinery and equipment	5,743	55.77	3.53	10.92	4.89
Transport equipment	3,999	46.96	1.63	7.15	2.58
Scientific equipment	2,243	48.02	4.01	14.00	3.97
Repair of capital goods	2,240	25.89	0.80	1.96	0.36
Electricity	3,644	64.71	0.93	3.10	3.24
Gas and steam	80	75.00	2.50	3.75	5.00
Water works and supply	293	10.58	0.68	1.02	0.68
Non conventional energy	4	25.00	25.00	25.00	0.00
Storage and warehousing	1,078	0.37	0.37	0.09	0.00
Sanitation	102	0.00	0.00	0.00	0.00
Motion pictures, etc	51	7.84	7.84	27.45	0.00
Laundry and others	94	0.00	0.00	0.00	0.00
Repair services	1,966	2.59	2.59	1.12	0.00
All industries	135,679	34.70	1.50	3.72	1.77

Source: Central Statistical Organization (*Annual Survey of Industries*) 1997.

3 The myth of benign state neglect

The central question that we address next is whether the international competitiveness and credibility, if any, that the ICT software and service firms have been able to establish over the years have been facilitated by the benign neglect or by proactive intervention of the state. This issue assumes importance because it has been argued that

India’s commendable performance in IT exports was the handiwork of the prophet of market. To appreciate the role of the state, one has to place India’s IT achievements against the backdrop of the national system of innovation (NSI) that evolved over the last fifty years. NSI refers to the national network of public and private institutions and policy initiatives for the development and diffusion of various technologies (Freeman 1987; Nelson 1993; Lundvall 1992). NSI in India has been instrumental in the creation of an extensive infrastructure base for the development of innovative and skill intensive activities like ICT. This includes, *interalia*, one of the largest and expanding mass of technically trained manpower, a network of centres of international reputation in specific sciences such as Indian Institute of Science, Indian Institute of Technologies (IITs) and national laboratories, as well as a number of software technology parks to facilitate the export of ICT software and services. Next is a brief account of the various state initiatives for the development of ICT and software sector in India.

3.1 Policy measures

Contrary to general perception, the importance of promoting software development, particularly for export, had been recognized by the erstwhile Department of Electronics (DoE). Suitable policies and programmes were put in place as far back as 1972 (Parthasarathi and Joseph 2002). During a period when very high tariff and non-tariff barriers were the rule, the import of computer systems on a duty-free basis and without indigenous clearance was permitted for firms dealing in software exports. Furthermore, in spite of restrictions on FDI, totally foreign-owned companies were permitted to set up software export operations, provided that they locate in the Santacruz electronics export processing zone (Government of India 1972). Later in January 1982, a software export promotion policy was initiated by the Department of Electronics (Government of India 1982).

The Computer Policy of 1984 gave further thrust to software development by underlining the need for institutional and policy support on a number of fronts. The policy, for example, called for the setting-up of a separate software development promotion agency (SDPA) under the Department of Electronics. The import of inputs needed for software development was made more liberal. However, the policy also emphasized that

> Effective software export promotion on a sustained basis can be effective in the long run only if it is planned as part of an overall software promotion scheme covering both export and internal requirements including import substitution. Also planning for software development is integrally connected with the plan for hardware development and system engineering (Government of India 1985).

After 1984, however, the accelerated growth of the computer industry posed numerous problems for the software industry, calling for a rationalization of the policies on the imports and development of software in the country, and using the domestic base for promoting software exports. At the same time, world trade in computers was expected to reach US$100 billion by 1990, more than half of which was estimated to be in software. India’s software export projections were based on a target of US$300 million, which corresponded to about 0.6 per cent of the world’s software trade. Based on this, it was felt that there was a need for more concrete policies for the promotion of software development and export. Thus, in 1986 an explicit policy was announced, identifying software as one of the key sectors in India's agenda for export promotion, and underlining the importance of an integrated development of software for the domestic and export markets (Government of India 1986). The policy had the following objectives:

- To promote software exports to a take a quantum jump and capture a sizeable share in international software markets;

- To promote the integrated development of software in the country for domestic as well as export markets;

- To simplify the existing procedures to enable the software industry to grow at a faster pace;

- To establish a strong base for the software industry in the country;

- To promote the use of the computer as a decisionmaking tool; to increase work efficiency and to promote appropriate applications which are of development catalysing nature with due regard to the long-term benefits of computerization to the country as a whole.

To achieve the objectives, the policy, emphasizing the need to simplify existing procedures, provided various commercial incentives to the software firms. These included tax holidays, income tax exemption on software exports, export subsidies, and duty-free import of hardware and software for 100 per cent export purposes.

With the initiation of economic reforms in the early 1990s, an assessment was made by the Finance Ministry. This highlighted the fact that, apart from the general orientation of industries towards export markets, India's comparative advantage was in software instead of hardware. Therefore, a major thrust was consciously given to software exports. Accordingly, new policy measures have been initiated *interalia* for the removal of entry barriers for foreign companies, lifting of restrictions on foreign technology transfers, participation of the private sector in policymaking, provisions to finance software development through equity and venture capital, reforms for faster and cheaper data communication facilities, and the reduction/rationalization of taxes, duties and tariffs, etc. (Narayanamurthy 2000).[9]

Along with policy reforms by the national government, various state governments (18 as of today) have enacted IT policies to promote ICT growth in the respective states. These generally focus on the key issues of infrastructure, electronic governance, IT education, and an environment for increasing IT proliferation.[10]

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9 Mention needs to be made of the substantial reduction in duties and tariffs across the board for components and sub-assemblies, zero duty for software imports and zero income tax on profits from software exports.

10 A detailed comparative analysis of the policies initiated by different state governments against the backdrop of the national policies would be highly rewarding, but falls beyond the scope of this paper and is thus reserved for future work. For details of policies enacted by different state governments, the reader may visit the home page of Nasscom at www.Nasscom.org.

3.2 Institutional interventions

In addition, the government introduced certain institutional interventions. No less than four major national task forces have studied all aspects of IT in the last four years and most of their recommendations have been acted on. More significantly, chief executives of leading private IT companies have been fully involved in these task forces. A number of government agencies involved in different aspects of IT were brought together into an integrated Ministry of Information Technology. This was followed by an IT Act to deal with a wide variety of issues relating to the IT industry (Parthasarathi 2001).

One notable improvement has been the establishment of software technology parks[11] (STP) to provide the necessary infrastructure for software export. Among the first were the parks at Bangalore, Pune and Bhubaneshwar, which were set up in August, October and December 1990, respectively. In 1991, four more STPs were started by the DoE at Noida, Gandhinagar, Trivandrum and Hyderabad.[12] Today, there are 18 such parks in different parts of the country and they play a significant role in software exports. The total number of units registered with the STPs increased from 164 in 1991 to 5,582 in 1999, accounting for about 68 per cent of India's IT exports (see Table 6). The facilities available in these STPs include, among others, modern computers and communications network which are beyond the reach of individual firms. The STPs also envisage a transparent policy environment and a package of concessions:

- Approvals given under the 'single window clearance' mechanism and permission of 100 per cent foreign equity;
- The STP authorities issue approvals for projects costing Rs 30 million or less with no foreign equity participation;
- Units eligible for five-year tax holiday with no value addition norms;
- Duty-free imports while domestic purchases are eligible for benefit of deemed exports; and
- Subcontracting of software development activity by STP permitted and sales in DTA permissible up to 25 per cent of the export (Oberoi 1991).

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[11] A software technology park (STP) is similar in all respects to a free trade zone, but exclusively set up for software. Specific objectives include:

- Establishing and managing infrastructural resources such as data communication facilities, core computer facilities, built-up space, common amenities, etc.
- Providing services (import certification, software valuation, project approvals, etc.) to users who undertake software development for export purposes.
- Promoting the development and export of software and software services through technology assessments, market analysis, marketing support, etc.
- Training professionals and encouraging design and development in software technology and engineering (Oberoi 1991).

[12] In 1991 there was also a policy change with regard to the management of the STPs. The earlier autonomous societies for managing each park were dissolved and a new society, Software Technology Park of India registered in June 1991, was given responsibility of managing all the STPs in the country through individual executives in each park. Under the new scheme, participating companies have the advantage of being fully involved in all decisionmaking processes, including fixing of rent, selection of hardware, etc. Each company is represented on the executive board which manages the park under the overall supervision of a governing council.

In June 2000, a new STP, consisting of a business support centre and an India infotech centre, was set up in Silicon Valley to facilitate software exports by small and medium-sized Indian firms to US.[13] The centre also fosters business relationships by providing access to American financial institutions, venture capital funds and specialized trade bodies to promote partnerships and strategic alliances between the US and Indian ICT software and service companies.

Table 6
Trend in IT export from units registered with software technology parks

Year	No. of units registered with STPs	Total exports from India ($ million)	Share of STP units in total exports
1991-92	164	164	na
1992-93	227	225	8
1993-94	269	330	12
1994-95	364	485	16
1995-96	521	734	29
1996-97	667	1,085	46
1997-98	844	1,750	54
1998-99	1,196	2,650	58
1999-00	5,582	3,900	68

3.3 Measures to address manpower bottleneck

While policy measures and the setting-up of the STPs have led to a substantial increase in the investment in ICT exports (Venkitesh 1995), the supply of technical manpower appeared to be a major constraint (Schware 1987; Sen 1995). Software development is a skill-intensive activity, albeit the intensity of skill requirements varies. Development of software involves broadly the following stages—requirement specification, prototyping, designing, coding, testing and maintenance. While the first few stages call for highly skilled manpower, the skill requirement is relatively low in the later stages (Schware 1987).

Traditionally, the main source of ICT and software professionals has been India’s public sector educational institutes such as the IITs (Indian institutes of technology) ITIs, (industrial training institutes) and engineering colleges. In 1984, the Sampath Committee reviewed the training needs for electronics and software, and in 1985 a standing committee on computer education was set up to plan further action. By 1996 new courses, introduced at about 400 institutions under the computer manpower development programme supported by DoE, had produced some 15,000 software personnel (Heeks 1996). The DoE’s support has not been restricted only to financial grants, but also involves curricula development. In addition to these courses, a number of enterprises and other institutions promoted by DoE, have provided training in software development. These include NCST and C-DAC (offering advanced software

13 *Economic Times* (2000).

engineering courses) and CMC Ltd., ETTDC, and NIC (providing routine software application training).

Furthermore, the government has permitted private investment in IT training since the early 1980s. By now 80 private companies operate over 4,000 privately-run training centres nationwide that offer different types of courses through networks of franchises (Kumar 2001b). These offer diplomas ranging from short-term specialized courses to longer-term basic courses. Given the uneven quality of training imparted by the private sector, DoE began an accreditation scheme to standardize the courses. A scheme called DOEACC was started in 1990 to provide accreditation to specified levels,[14] and by January 2000, a total of 699 institutes had been accredited. The DOEACC Society conducts examinations for the four levels twice a year and awards certificates/diplomas (Kumar 2001b). These institutes primarily cater to the middle- and lower-level manpower needs of the IT industry. At the same time, seven Indian Institutes of Information Technologies (IIIT) were set up to provide academic training on par with the IITs. Available estimates indicate that in 1999 there were over 1,832 educational institutions, contributing more than 67,785 trained computer software professionals per year (Nasscom 1999a). The structure of the current turnout of technical manpower from these institutes indicates that the three categories, viz., B-techs, diploma and the ITI certificate holders, account for nearly 70 per cent of the total IT force; B-techs account for as much as 24 per cent, while the share of M-techs and PhD holders is only 3.14 and 0.14 per cent, respectively.

Another notable intervention by the state was the provision of data communication and networking infrastructure to the educational and research community and to the software industry. This was critical to the country's IT development. The Education and Research Network (ERNET) project was initiated in 1986 with the participation of NCST Mumbai, IISc Bangalore, five IITs, and support of DoE and the UNDP with the objective of enhancing the national capability in computer communications. ERNET has evolved into a separate institution which now provides computer networking services to over 80,000 users in 750 academic and research institutions with its dedicated satellite data transfer backbone (Kumar 2001b).

3.4 Measures to address software piracy

Until recently, India's weak copyright regime has facilitated the proliferation of software piracy. This, in turn, has been a disincentive for firms to develop software products. The magnitude of the problem is illustrated by the Lotus Development Corporation, who estimate that out of 150,000 copies of Lotus 1-2-3 in India in the early 1990s, 140,000 were pirated (Schware 1992). To address the problem, the government initiated a series of measures, including the protection of the computer software copyright under the Indian Copyright Act of 1957. Major changes were made to the law in 1994, making it a punishable act to make or distribute copies of copyrighted software, with a minimum jail term of 7 days extendable up to 3 years, or a fine ranging from Rs 0.05 million to Rs 0.2 million. In addition, the government, in cooperation with the National Association of Software and Service Companies (Nasscom) conducts regular antipiracy raids to discourage software piracy. As a result, the piracy rate has dropped from 89 per cent in 1993 to 60 per cent 1997 (Nasscom 1999a).

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[14] These include the O-basic course, A-advanced diploma, B-MCA level, and C-m.tech level.

It may be myopic to attribute the IT dynamism entirely to state initiatives. Other factors were also involved, including, but not limited to, the availability of a highly-skilled English speaking labour force at a wage rate much lower than in the developed countries; the time difference between India and the US, still a major export market. On the demand side, the world market for IT has been increasing at a much faster rate during the past decade because of the Y2K problem, and so on. While state initiatives laid the foundation for faster growth, the industry associations,[15] particularly the Nasscom, have played an important role. In addition to lobbying at central and state government levels, the Nasscom was also heavily involved in projecting India's image in the global IT market. For example, in 1993 Nasscom appointed a full-time firm in Washington to lobby for the participation of Indian firms in large international IT exhibitions and to promote India's capabilities in the sphere of IT. Nasscom's influence in getting the visa rules relaxed by the developed countries, especially USA, is well known. Also, in 1994 Nasscom initiated the antipiracy measures in India, when Intellectual Property Rights (IPR) became a major issue in the Indo-US relations. To take up the campaign against software piracy, it conducted a number of well-publicized raids.[16]

From the foregoing, it is obvious that the international competitiveness and credibility, if any, achieved by India's IT sector over the last decade has to be viewed in the context of the national system of innovation, where the state played a key role. The form and content of state intervention, however, has changed since 1991-92, when the state began to facilitate private sector initiatives, while simultaneously reducing its own direct participatory role. Moreover, the focus of the state has been mainly on the promotion of the ICT software and service sector for foreign exchange earning purposes rather than foreign exchange saving purposes, as in the 1980s. But what seemingly was overlooked in the obsessively export-oriented strategy is a concerted effort to diffuse IT into different sectors of the economy so as to reap the benefits of this powerful technology for improved efficiency, productivity, competitiveness and growth.

4 The myth of liberalism induced export growth

Most of the studies on the Indian ICT sector have characterized its dynamism as a phenomenon of the last decade, whereas its software exports doubled in every three years even during the 1980s (Joseph 1997). If the analysis is limited to the last decade, studies have attributed the growth of the sector to the liberalization policies adopted by the state in the early 1990s. Next, by making use of export data for 1980-99, we attempt to determine if the export growth acceleration is a post-liberalization phenomenon. In this exercise we make use of the Nasscom data on IT exports, which have been used both by the task forces and other researchers.

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[15] Initially there was the Computer Society of India, essentially an association of academics and professionals, which did not address many of the issues faced by the industry. Hence a new association known as the Manufacturers Association of Information Technology (MAIT), consisting of both hardware and software firms, was formed in 1982. Later an association, currently known as Nasscom, was formed to address specific issues being faced by the software and service companies.

[16] For a detailed account of Nasscom activities in promoting IT and the role played by the late Mr Dewang Metha, see *Business India* (19 February to 4 March 2001).

We have estimated a semi-log function since it can be extended to a second-degree polynomial as a case of varying parameter regression. This polynomial can then be used to test for acceleration, deceleration or constant growth rate as restrictions on the parameters (Reddy 1978). The logic behind the methodology adopted may be explained as follows. If the growth rate is constant, then it can be estimated by semi-log function:

$$\ln Y_t = a_0 + a_1 t + u_t \qquad (1)$$

If the growth rate changes over time, then the regression coefficient a_1 is not constant but varies. This varying parameter can be modelled as a function of time (Maddala 1977). The simplest relationship is to postulate a linear relationship between a_1 and t (time) This would mean

$$a_1 = a_2 + a_3 t \qquad (2)$$

Substituting (2) in (1) we get

$$\ln Y_t = a_0 + a_2 t + a_3 t^2 + u_t \qquad (3)$$

Note that if a_2 and a_3 are significantly different from zero, then the growth rate is not constant. The growth rate is accelerating if $a_3>0$ and decelerating if $a_3<0$. Moreover this functional form can also be used for the calculation of the year of maximum/minimum.

$$d(\ln Y_t)/dt = 0$$

$$a_2 + 2a_3 t = 0$$

Therefore $t = -a_2/2a_3$.

The value of t can be used for the calculation of the year in which the growth rate accelerates or decelerates. The estimated result of equation (3) is as follows:

$$\text{Export growth} = 4.3307 - 0.1528t + .0078t^2 .$$

From the above estimated equation, we have calculated the year of acceleration using the method given above. The year of acceleration is found to be 1989 which tends to suggest that the acceleration in the growth rate of India’s software exports has been in motion even before the introduction of the globalization policies in the 1990s.

5 Growth of IT and the economy

The growth in IT exports observed over the last decade has created much euphoria and unprecedented media attention. In this context, it is only appropriate that we go beyond casual observations, and attempt to place the IT sector in its rightful place, a prerequisite for making informed policy-decisions. This calls for an understanding of the real contribution of this sector to the economy as a whole.

For an economist, the prime reason for the euphoria appears to be the growth in export earnings and the unique credibility India enjoys in the global IT market. If so, a question must be lingering in the minds of readers. Non-resident Indians (NRIs) have significant credibility in countries like the US and they make remittances valued at least three times that of the software exports. Why, then, is there no similar excitement over the foreign exchange earned by the NRIs? Even though the software sector brings in foreign exchange, the state had already invested substantially in building up the human as well as the physical capital that facilitated the IT export upswing. To this, one must add the series of fiscal concessions provided by the state. Yet, India has workers in plantations, fisheries, leather goods, and diamond cutting plants, etc. who earn substantial foreign exchange without any significant investment by the state towards their skill formation. So why is there no hype about the foreign exchange earned by them? Perhaps the underlying reasoning may be best summarized in economic terms, as 'a dollar worth of potato chips is not equal to a dollar worth of micro chips'. Unlike the traditional sectors, the IT sector is known for its spillover benefits and linkages to the rest of the economy.

Whether the IT sector under the export-oriented growth strategy generates any spillovers and linkages with the rest of the economy is an issue that needs separate inquiry. In the absence of serious research, no definite conclusion is warranted. Nonetheless, based on preliminary data, some propositions may be in order. The growth of the sector, mostly driven by the export market, remains an enclave in the economy with hardly any forward or backward linkages. This is because the Indian IT industry is currently locked to low-level design, coding and maintenance, where linkages to rest of the economy may be negligible (D'Costa 2001). In terms of location, even today almost 90 per cent of the software development and export activity is confined to four major metropolitans (Bangalore, Mumbai, Delhi and Chennai) and this tends to accentuate rather than mitigate regional disparities (see Table 7). Thus, as observed by Mansell (1999), the export-oriented IT growth strategies seem to have generated only a few spillover benefits.

The macroeconomic implications of the IT export boom may be viewed in a more precise way from two angles—its implications on the product market and on the labour market. We have the 'Dutch disease' models in trade theory, which can be used as an analytical tool to reflect on both of these implications in the short run. The central argument of these models is that windfall booms of external income can cause problems. They may result in an unexpected de-industrialization of the economy. The literature on Dutch disease and the 'resource curse thesis' underline such backwash effects of a primary commodity boom (Corden 1984 and Van Wijnbergen 1984).[17]

The Dutch disease syndrome is explained in terms of two symptomatic effects of an export upswing, namely, the 'spending effect' and the 'resource movement effect' (Corden and Neary 1982; Fardmanesh 1991). Spending the extra income from an export boom tends to increase prices of non-tradable goods vis-à-vis tradable goods, leading to an appreciation and erosion of the competitiveness of the tradable sector. The 'spending effect' refers to the contraction of non-booming tradable sectors, reflecting the real appreciation. The tendency for the prices of production factors and non-tradables to increase adversely affect the non-booming tradable sectors exposed to external

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17 'Dutch disease' economics is so named after the experience of the Netherlands in the 1960s, when the country experienced a boom of natural gas discoveries. The more the Netherlands developed its natural gas production, the more depressed its manufacturers of traded goods became (Lindert 1986). Dutch disease models were later found to have general applicability in the context of oil exporters, and countries experiencing primary export upswings in general (Kamas 1986; Fardmanesh 1991; Usui 1996).

competition. The expansion and increased profitability of the booming sector draws out the mobile factor (labour) from the other sectors and hikes up its price. The resulting contraction of the stagnating tradable sectors, caused by the heightened competition on production factors, is referred to as the 'resource movement effect'. Analytically, the spending effect deals with implications on the product market whereas resource movement effect is associated with the factor market, or more specifically, the labour market. Here it may be noted that these two effects are neither mutually exclusive nor do they operate in isolation. Instead, each reinforces the other and the ultimate impact will be a combined effect of both. Hence, our distinction between product market (spending effect) and factor market (resource movement effect) may be considered as pedagogical scaffolding.

Table 7
Distribution of software sales and exports across major locations in India

	Sales %		Exports %	
Location	1997	1998	1997	1998
Bangalore	33.9	27.9	30.3	29.7
Mumbai	24.3	24.7	27.5	24.0
Delhi/Noida	15.9	20.3	15.3	18.5
Chennai	14.8	16.8	15.5	17.3
Hyderabad	4.2	5.4	5.3	6.3
Calcutta	3.3	2.3	1.5	1.3
Others	3.6	2.6	4.6	2.9

Source: Estimated from Nasscom (1999b).

5.1 IT boom and the product market

Impacts on the product market operate essentially through price increases and the accompanying real appreciation. Increased export earnings can lead to a rise in exchange reserves and money supply, causing domestic inflation, which in turn leads to real appreciation and makes domestic producers less competitive. The decline in industrial growth and exports since 1995 in an environment of increased IT export earnings and growing foreign exchange reserves have been attributed to support the theory of an IT export induced Dutch disease in India (Mukherji 2000). To empirically gauge the veracity of this argument, we need to place IT exports in the context of the external sector of the economy.

Table 8 presents the breakdown of each major item contributing to the reduction in current account deficit and the increase in foreign exchange reserves. Some interesting inferences can be made. To begin with, given the fact that trade deficit almost doubled during the period under consideration, commodity trade had no positive impact on the reduction observed in the current account deficit. The major contribution, notwithstanding the yawning trade gap, was made by the invisibles, where net private transfers recorded an almost six-fold increase during the period under consideration (see Table 8). Another item that has had a positive impact on the invisibles is miscellaneous services, an item which includes IT exports. It may be noted that in the final year the net export earnings from miscellaneous services are much less than total IT exports, which is only one of the items in this category. This takes us to a close look at the net export earnings from IT.

Table 8
IT exports and India's external balance

	1990-91	1999-2000
	(million US dollars)	
Trade balance	-9,438	-17,098
Invisible (net)	-242	12,935
Of which:		
Private transfers	2,069	12,256
Miscellaneous services	161	3,198
IT exports	128	3,900
Current account deficit	-9,680	-4,163
Total capital account	7,056	10,242
Overall balance	-2,492	6,402
Foreign exchange reserves	5,384	38,036

Notes: All items except IT exports are given as net. IT exports are from Nasscom (1999b)

Source: Reserve Bank of India (*RBI Bulletin*, different issues).

Table 9
Trend in export import and import export ratio for a sample of software firms

Year	Total exports	Total imports	Import export ratio
1992-93 (20)	124.34	75.18	0.60
1993-94 (34)	253.28	146.31	0.58
1994-95 (59)	429.70	238.35	0.55
1995-96 (74)	667.27	412.25	0.62
1996-97 (87)	894.32	539.57	0.60
1997-98 (115)	1,840.45	960.70	0.52
1998-99 (155)	3,426.52	1,508.53	0.44

Notes: Total exports and imports given in Rs crores. Figures in brackets give the number of firms in the sample.

Source: Estimates based on PROWESS (Center for Monitoring Indian Economy 2000).

Despite the importance of IT, reliable data on IT trade (export and import) are difficult to obtain. There are three major data sources pertaining to the software trade: the Ministry of Information Technology, the Nasscom and the Reserve Bank of India (RBI). For reasons unknown, the first two sources remain silent about software imports. But the Reserve Bank of India, which has provided data on software exports since the fiscal year 1997/8, reports that software imports totalled US$223 million, US$348 million and US$468 million, respectively, for the financial years 1997, 1998 and 1999. This appears negligible. These figures, however, pose problems. First, the import of software need not necessarily be by the software exporters. Second, there is substantial import of hardware associated with software export, which cannot be isolated from the RBI data. Third, data by RBI may not include software embodied in imported capital goods. Viewed thus, the RBI data may be grossly underestimated and thus not reflect reality. For our purposes, therefore, the only alternative is to depend on import data provided by the software firms at the firm-level.

We obtained the firm-level data from the computerized database of the Centre for Monitoring Indian Economy. Table 9 presents data on the import intensity of a representative set of firms. It is evident that total exports by the sample of firms increased from Rs 124 crores in 1992/3 to over Rs 3,400 crores in 1998/9. This represents an annual compound growth rate of over 73 per cent (in rupee terms) and is in tune with the growth rates obtained from Nasscom's export data for the sector as a whole. At the same time, imports similarly recorded an increase of 53.5 per cent, resulting in an import-export ratio of around 60 per cent until 1996-97. Despite the decline in import intensity after 1996/7, it is too early to determine if this marks the beginning of a negative trend. Nonetheless, even today, import intensity is as high is 44 per cent, a fact barely noted by existing studies. If the data in Table 9 are an indication, one could safely conclude that despite the recent decline in import intensity, the net earnings from India's software exports constitute no more than 55 per cent of gross exports.

If net earnings from software exports account for only 55 per cent, then the cumulative contribution of IT to foreign exchange reserves can only be in the magnitude of US$6.3 billion from 1990/1 to 1999/2000, or 16 per cent of total reserves. It also needs to be noted that the export estimates used above are based on Nasscom data which can be substantially overestimated (Parthasarathi and Joseph 2002).[18] If this overestimation is taken into account, net IT contribution to the external sector drops to about US$4.5 billion for the last decade. Based on the evidence presented so far, it is possible that the country's net IT export earnings will grow to a level which will induce, through the spending effect, a major adverse impact on the growth and competitiveness of other sectors (product market). Next, we examine implications of the IT upsurge on other sectors of the economy through the resource movement effect.

5.2 IT boom and the factor (labour) market

First, it should be noted that IT is a highly labour-intensive activity. An examination of the share of labour (wages) in the gross value added for 155 IT firms in 1998/9 shows that wages accounted for as much as 66 per cent. Unlike most other labour-intensive industries, the IT sector employs mostly skilled labour, albeit with a varying skill level depending on the nature of the firm's activities. Available empirical evidence suggests that the IT export boom of the last decade has to be seen in the context of India's labour cost advantage (see Table 10). Needless to add, the IT sector upswing has led to increases both in the demand for labour and in the wage rate.[19] The shortage of IT employees has encouraged professionals with training in chemical engineering, civil engineering, mechanical engineering, etc. to migrate to the IT sector.

The implications of the increased IT labour demand and the rising wage levels on the one hand, and the subsequent transfer of professional from other sectors on the other hand may be examined in terms of the resource movement effect.[20] It should, however,

[18] Based on data obtained from a sample of 155 firms, it has been shown that the extent of overestimation in exports during 1998-99 was some 33 per cent.

[19] Available evidence suggests that in the 1990s wages and salaries of IT professionals have grown at a rate of 30 to 35 per cent.

[20] This section draws heavily from Joseph and Harilal (2001).

be remembered that the resource movement effect is limited to economic sectors that compete with IT for skilled manpower. For analytical purposes, the sectors requiring technical manpower are divided into two broad groups: (i) those engaged in the production of services and (ii) those engaged in the production of goods (such as hardware, communication, control instrumentation, etc). The service sector, in turn, is further subdivided into: (i) the software sector,[21] and (ii) other service-producing sectors (research, teaching, training, etc).

In terms of the labour movement effect, the boom in the software export sector, *interalia* reflecting the exogenous increase in global demand, produces an additional demand for labour in that sector. This raises the wage rate, and naturally higher software sector wages attract labour (which is mobile) from other manpower-competing sectors. Thus, salaries for technical professionals increase. As other economic sectors are not experiencing an upswing, they adjust to the new circumstances (in the short run) by reducing the number of employees, thus reducing output. On the other hand, employment in the software sector (and hence output) increases. The observed rise in wage rate is unlikely to have any adverse impact on the software-exporting firms because wage rates globally are still higher than locally. The wage difference, therefore, continues to give the software exporting firms a competitive advantage.[22]

Our argument that there could be a reduction in the employment and output of other service sectors competing for the skilled manpower could be better appreciated if viewed in the context of the recent finding made by the task force on human resource development in IT, which reported a deficit of about 10,000 teachers in software training.[23] How to account for such a shortage? Given the fact that technical manpower for software development and software training is substitutable, and that labour is mobile, there seems to be a preference for employment in the software industry as compared to software training which is less rewarding at present.

The resource movement effect could also lead to reduced employment and output in the goods-producing sector which includes hardware, communications, etc. According to Nasscom, production of hardware and peripherals together recorded an annual compound growth rate (in dollar terms) of 10.5 per cent during 1994-95 to 1998-99, less than one-fourth of the growth rate for IT exports. Here again, an overestimation in the Nasscom data may be possible. To substantiate further, in 1994, according to the erstwhile Department of Electronics, total production of data processing systems (including peripherals) amounted to only Rs 13,000 million (Government of India 1996), whereas according to Nasscom (1999b) the corresponding figure in 1994-95 was Rs 28,570 million. This implies an overestimation of more than 100 per cent.

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21 It is possible to divide software into those meant for export and domestic market, and the same model may be employed to explore the plausible implications of software export on the production of software for domestic market. Such an attempt is made in Joseph (1996).

22 The prediction of general rise in wage rates may not be robust if the labour market is segmented (assumed so here). The reality is likely to be that firms in sectors competing for skilled labour would be left with the choice that (i) they either pay salaries on par with the software firms, or (ii) by paying lower wages, be satisfied with second best workers. While this is an empirical question, one could safely infer that either strategies could have adverse effects on firms operating in high-skilled sectors.

23 See *Economic Times* (2001).

Table 10
IT labour costs across different countries in 1995

	Switzerland	USA	Canada	UK	Ireland	Greece	India
	(US$ per annum)						
Project leader	74,000	54,000	39,000	39,000	43,000	24,000	23,000
Business analyst	74,000	38,000	36,000	37,000	36,000	28,000	21,000
Systems analyst	74,000	48,000	32,000	34,000	36,000	15,000	14,000
Systems designer	67,000	55,000	36,000	34,000	31,000	15,000	11,000
Development programmer	56,000	41,000	29,000	29,000	21,000	13,000	8,000
Support programmer	56,000	37,000	26,000	25,000	21,000	15,000	8,000
Network analyst/designer	67,000	49,000	32,000	31,000	26,000	15,000	14,000
Quality assurance specialist	71,000	50,000	28,000	33,000	29,000	15,000	14,000
Database data analyst	67,000	50,000	32,000	22,000	29,000	24,000	17,000
Metrics/process specialist	74,000	48,000	29,000	31,000	na	15,000	17,000
Documentation/training staff	59,000	36,000	26,000	21,000	na	15,000	8,000
Test engineer	59,000	47,000	25,000	24,000	na	13,000	8,000

Note: Figures are averages for 1995. They are likely to rise circa 5-10 per cent per annum, with rates being slightly higher in lower-income countries.

Source: Heeks (1996) adapted from Rubin *et al.* (1996).

The plausible adverse impact of resource movement on hardware production supports the observation made by the IT task force, which reported ‘a steady decline of the IT hardware industry over the 7-8 years due to faulty and deficit policies, should be immediately reversed into a growth path through the introduction by a set of policies conducive to growth and international competitiveness’. Thus today we have an IT revolution with a lagging hardware sector.[24] The fate of communications equipment has not been much different, either. The task force, while attributing hardware’s negligible growth entirely to faulty policies, seems to have failed to recognize the labour market linkage between the hardware and software sector.

From the discussion so far. the following tentative conclusion may be made. To begin with, the net foreign exchange contribution of the IT sector has been much lower than what has been often claimed in terms of gross exports. While the adverse impact on other sectors from the spending effect might have been limited, there is some merit in the argument that IT boom might have had a dampening effect on the cost and competitiveness of other sectors through the resource movement effect. Again, this might have been confined mostly to those sectors which compete with the IT sector for skilled manpower. Thus, while the IT has the potential of contributing towards productivity and growth, the short-term impact of the export-oriented growth strategy of ICT in India seems to have been in terms of a negative influence on sectors needing skilled manpower.

24 The poor performance of the hardware sector calls for a separate inquiry. Suffice to note here that seeds of the stagnation in the 1990s were already sown in the 1980s itself. See Joseph (1987) for details.

6 Liberalism induced innovative performance

It has been argued in the literature that liberal economic policies associated with export orientation facilitate technological advancement and hence faster growth of output (Fransman 1985). The positive correlation between export orientation and innovation is based on the premise that the competitive pressure associated with exports induces improvements in product quality and reductions in cost. The opportunities to learn from consumers and other firms also are an inducement to innovation. Moreover, with expanding markets, firms can benefit from the economies of scale and increased division of labour. To this, one may also add the greater availability of foreign exchange facilitating the import of necessary inputs needed for exports. While the literature in this area is enormous and still growing, Rodrik (1995) states that the analytical foundations of most studies have been too ambiguous and the preferred method ranges from casual appeal to common sense. Yet, we are living in a world wherein export-oriented policies have been religiously pursued as the panacea to most of the problems faced by the developing world, even in the big emerging markets of India and China. In this context, the relevance of an empirical verification of this issue cannot be overemphasized.

As the first step in the empirical analysis, we have to address the issue of defining innovative performance. It has been generally acknowledged in the literature that the primary manifestation of innovative performance is improvement in productivity. Productivity can be defined either in terms of partial productivity (output per unit of any of the inputs like labour or capital) or total factor productivity. In the present context, given the human capital-intensive nature of the process involved, we could measure innovative performance in terms of labour productivity (output per unit of labour employed). However, this measure is not without its own problems and there are limitations for comparisons across time and across companies. First, a variation in labour productivity across firms may be caused by differences in the quality of labour. Second, diverging labour productivity over time may be due to inflation or exchange rate fluctuations. Moreover, because of India's excess labour demand in the software industry, compensation levels have increased 20-30 per cent per annum during the post-1995 period. Thus, the estimated growth rate in labour productivity can exceed the rate for improvements in efficiency. Therefore, following Kumar (2001a), it is possible to estimate productivity in terms of revenue per unit of wage bill. In the empirical estimation that follows, we use these two alternate labour productivity measures.

The influence of export-oriented strategy is measured in terms of the following variables:

- Export intensity, measured as the proportion of output that is exported;
- Import intensity, measured in terms of the ratio of total imports to sales;
- Foreign collaboration dummy which takes the value one for firms having foreign collaboration and zero for those with no foreign collaboration; and
- MNC dummy which takes the value one if foreign equity share is more than 10 per cent and zero otherwise (this in tune with IMF classification).

As per neoliberal theories, all these variables are hypothesized to have a positive effect on innovative performance. In terms of the theoretical premises of the structureconduct-performance paradigm, innovative performance (labour productivity) is however, affected by a number of other factors that are specific to the firm, the industry, and the economy. Given the fact that we are dealing with a cross-section of firms operating in one specific industry, the industry-specific and economy-wide factors are assumed to be the same for all firms and are not included in our analysis. Next is a brief description of other firm-specific factors incorporated in the analysis.

Ever since the pioneering work by Galbraith (1952), the literature on the relationship between firm size and innovation is growing, but without a consensus on the issue.[25] The fact that there are inter-industry differences for innovative opportunities across different industries also depends on the method used to gauge innovation. In the case of conventional industries, firm size, as measured by the firm's gross fixed assets, is generally hypothesized to have a positive influence on innovative performance, because of the possible economies of scale associated with these industries. Given the techno-economic characteristics of the new high-tech industries like ICT and software services, biotechnology, etc., it may be possible that size does not have a major bearing on innovative performance. Hence we hypothesise that the relationship between innovative performance and size can be either negative or positive. To test for the existence of any non-linear relationship, we have also included a square term in the estimated model.

The role of R&D in influencing innovative performance is obvious, and we have incorporated R&D intensity (R&D as a proportion of sales) in the model. In a skill-intensive industry like IT software and services, one can postulate a positive relationship between innovative performance and the skill profile of the firms. However, the available dataset does not permit us to precisely define skill profile in terms of academic qualifications and experience of the employees. Hypothesizing a positive relationship between innovative performance and skill intensity, we measure the ratio of software employees to total employees as a proxy for skill intensity. We have also included the age of the firms to discern for the possible effect of accumulated experience. Finally, we have incorporated the ratio of selling cost to sales to highlight the influence of sales efforts.

The influence of the different variables has been empirically verified using the following regression equation:

$$Productivity = a_0 + a_1 export\ Intensity + a_2\ import\ Intensity + a_3 colldum + a_4 mncdum + a_5 size + a_6 size^2\ a_7\ skill + a_8 sellingcost + a_9\ age + error\ term.$$

6.1 Results of the model

Table 11 presents the results of the two models. In the model I, the innovative performance is measured in terms of labour productivity and in model II, in terms of revenue per unit of wage bill. Model I has been estimated using the new dataset that we have developed by merging the Nasscom and CMIE data set for two years, namely 1997-98 and 1998-99, whereas the second model has been estimated by pooling the Nasscom data for the period 1994-95 to 1998-99

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25 For a recent survey of studies with focus on methodological issues, the interested reader may refer to Cohen (1995)

To begin with, the analysis reveals that export intensity, the most important variable in the model, has a negative and statistically significant sign in both of the models. This tends to suggest that export orientation, if any, has a dampening effect on the innovative performance of the firms. Thus, the nature of export demand has not been conducive to enhancing innovative performance of the firms. This finding supports the observations made in earlier studies, which report that the comparative advantage of Indian firms is in the export of services such as customized software development, with only a well known proprietary-package products in the international market (Arora and Asundi 1999). Here again, the emphasis of Indian firms is at the lower end of the value chain, focussing on low design, coding and maintenance aspects. (Kattuman and Iyer 2001). Thus the Indian ICT and software services sector competes primarily on the cost advantage factor, with very limited innovation capacity (Mahajan (2000). As a result, the revenue per employee in the ICT software and services industry is estimated in 1999 to be only US$16,000, whereas comparable figures are almost ten times higher for Israel (US$150,000) and more than four times (US$70,000) for Ireland (Arora *et al.* 2001) The empirical evidence, therefore, underscores the need for greater focus on the domestic market to promote innovative performance of our ICT software and service industry where opportunities for much higher revenue per employee exist, but are being harvested by CMC contracts for railway passenger reservation systems and railway freight operation information systems (Parthasarathi and Joseph 2002).

Among the other variables incorporated to gauge the influence of export-oriented growth strategy, import intensity was found to have a statistically significant positive sign in the first model, whereas it was not significant in the second model. If the result of the first model is any indication, we may conclude that firms with a better innovation record also have high import intensity. The coefficient of MNC dummy was found to be negative statistically significant in the second model, but not statistically significant in the first model. This also points to the nature of activities undertaken by the foreign firms. The coefficient of collaboration dummy, though positive, was not statistically significant in any of the equations. Both these findings point to the fact that greater foreign participation or technology import is not likely to have any significant bearing on the innovation performance of the ICT software and service firms in India.

Among the firm specific variables, size is found to be positive and statistically significant in both equations. While the selling cost turned out to be significant in the first model, it was not significant in the second model. The statistically significant positive sign of size underscores the scale factor in promoting innovative performance. The negative influence of selling costs has to be viewed against the current structure of exports wherein software services, especially on-site services, dominate. Selling cost is relevant only in the case of software products. It has been noted that in the case of high value-added software products, large multinational companies dominate the market and they spend up to 60-65 per cent of the price component of packages on marketing and distribution (Kumar 2001a).

The estimated model also shows that age does not have any significant influence on innovative performance. It is surprising to note that the estimated coefficient for skill is negative (though not statistically significant). This probably reflects that fact that the nature of data that we had was not sufficient to capture the skill profile in a precise manner. Until such a detailed analysis is carried out, a robust conclusion is not warranted. The coefficient of R&D intensity also turned out to be statistically not significant. This has to be viewed against the fact that there are only a very few firms engaged in R&D and even their R&D intensity is not very high.

Table 11
Results of the regression models on innovative performance

Variables	Model 1	Model 2
Export intensity	**-0.0374** (-2.484)	**-27.800** (-2.434)
Import intensity	**0. 0471** (1.768)	-12.272 (-0.760)
Collaboration dummy	0.0075 (0.683)	-14.963 (-1.300)
MNC dummy	-0.0054 (-0.477)	**-17.986** (-1.889)
Size	**0.0209** (3.225)	**6.475** (2.682)
Size2	-0.0005 (-0.389)	0.512 (0.717)
Skill intensity	-0.0252 (-1.112)	
Selling costs	**-0.1359** (-2.174)	-3.879 (-0.235)
R&D intensity	-0.0003 (-0.002)	-0.909 (-0.391)
Age	9.8006 (0.809)	-0.007 (-0.605)
Constant	**0.0617** (3.451)	**29.958** (5.701)
Number of observations	108	452
R2	0.39	0.50
F	6.28	2.36

Notes: Figures in brackets show t values. Coefficients given in bold are statistically significant at least at 10 per cent level.

7 Concluding observations

While there is an increasing realization of the potential that IT offers for human welfare, IT induced productivity and growth are limited to the developed world. Even though the international digital divide is a reality, it is argued that there are certain specific characteristics of the new technology which leave scope for mitigating, if not totally bridging, the gap as long as appropriate policies are in place. This calls for a concerted action by the different agents involved—the government and non-governmental organizations—and the private sector. While such multi-institutional stakeholder networks could be instrumental in harnessing the new technology for development (and attempts have been made by governmental and non-governmental organizations), there is a paucity of efforts to assess their impact or to suggest measures for accelerating the process of IT diffusion. Available evidence suggests that in the current era of globalization, firms in India's manufacturing sector are also in the process of harnessing the new technology for improving productivity and competitiveness. But what has been the return to these investments? How to account for the inter-firm and inter-industry variation in the levels of ICT usage? What are the constraints and what policy initiatives are called for in order to hasten the diffusion process? These are some of the issues on which detailed research is required for informed policymaking.

The perils of the export-oriented IT growth strategy followed to date in India are evident from the findings of a recent study by IMF (2001), which reports that IT-using countries tend to benefit somewhat more than IT-producing countries. The disappointing welfare gains for IT producers are attributed to a deterioration in the terms of trade. Based on a panel data for a sample of 41 countries over the years 1992-99, estimates have shown that the increase in consumer surplus is quite large, already accounting for several percentage points in the GDP. Countries with largest consumer surplus gain (more than 3.5 per cent of GDP) are the United States, United Kingdom, Singapore, Australia and New Zealand.

India, in adopting to become a major producer by drawing on the strengths of the national system of innovation that had evolved over the years, had to be among the losers. Export-oriented growth strategy notwithstanding; the real contribution in terms of net export earnings has been much lower than gross exports. This was mainly caused by the nature of the export demand which in turn necessitated large-scale imports and the dominance of onsite services. The study finds that while low net export earnings reduced the possibility of real appreciation, the IT-sector boom is likely to have had adverse effect on other economic sectors needing skilled labour, at least in the short run, because of the resource movement effect. Thus, while an IT induced development strategy could have been instrumental in enhancing efficiency, productivity and growth, the strategy of export-oriented IT growth seems to have had an adverse impact on other sectors.

We have also argued that the country's export-oriented growth strategy had an adverse effect on the innovative performance of firms. This perhaps points to the nature and composition of the export demand, wherein the tasks assigned to Indian firms by foreign counterparts were did not encourage innovative efforts at all. This finding tends to underscore the need to recognize the complementary role of the domestic market in promoting innovation and exports on the one hand, and IT induced productivity and growth on the other. Hence, there is need for a policy which focuses on ICT for development. This, in turn, calls for comprehending the social marginal product of a dollar worth of IT exports vis-à-vis its domestic consumption.

In this context, it is encouraging to note that the report by the taskforce on knowledge society (Planning Commission 2001) marks a major turnaround in our thinking towards ICT. It underlines the need for harnessing the new technologies (like IT, Bio Technology, space and materials technology) and management structures for the generation of wealth and employment on the one hand and societal transformation and knowledge protection on the other. The report, while exhaustive in its coverage, ambitious in its targets and futuristic in its perspective, appears to be ambiguous in terms of the implementation strategy even to a modest critique. Hence, it is likely to remain as an esoteric report with limited impact, unless appropriate implementation strategies are introduced by taking the different stakeholders into play. While a number of issues addressed in the report fall under the jurisdiction of the state governments, the apparent topdown approach appears contradictory to the basic tenants of an information society. Instead of the taskforce identifying a few states as ‘success pilots’ and imposing the articulated strategy, different states should have been encouraged to draw up their own action plans against the broad contours set by the taskforce, but also by taking into account the specificities of each state. Perhaps we are yet to realize that the ‘Delhi-centric’ approach has to give way to a more decentralized approach if we are to effectively address any of the developmental issues, including ICT diffusion.

Appendix

A1 Bridging the digital divide: Selected experiments from Indian states[26]

Andhra Pradesh

The state of Andhra Pradesh, which includes 23 districts, 1,125 *mandals*, 295 assembly constituencies and 28,245 revenue villages, has been digitized to a certain level. These are being connected a state Wide Area Network called APSWAN. With the establishment of such a network, the state administration is geared up to tackle several issues and help extend the reach of people and government alike. Further, over 70 marketplaces across the state are computerized and networked to the Agricultural Market Yard department at the state government headquarters. This provides total on-line connectivity to monitor arrivals of the commodities, the prevailing prices etc. at head quarters as well as at the market yards. This enables the farmer to determine the prices at which to sell his produce or direct his produce to another market to fetch a better price. The farmer also gets information about various services available at the market yard such as tariffs for storage facility, weighing and handling charges, etc. The process thus eliminates the commission agents and exploitation of the farmer. The information available in the network enables the government not only to monitor the functioning of the markets, but also helps in formulating appropriate strategic plans for the state. Since the system generates all the necessary reports online, it enables the government agencies to improve efficiency of operations and extend better services to the farmers. Therefore AP government is rightly giving priority to connectivity. The Karnataka government has also undertaken a similar project.

Madhya Pradesh

The feasibility of universal access to information has been demonstrated by the Gyandoot Doctom project in Madhya Pradesh. This experiment is carried out successfully in Dhar district. A total of 21 centres in five blocks in Dhar district have been wired with locally made servers and multimedia kits for each centre in a cost effective way. The centres are located in the *panchayat ghar* and electricity costs are borne by the *panchayats*. The person who manages the centre pays the cost of telephone links with the state wide Intranet and villagers are required to pay a nominal charge for obtaining government related services such as access to documents like land records, regular market updates and other useful information. This substantially reduces the role of middlemen. Each centre caters to 15 gram *panchayat* situated in 30 villages having a potential clientele of around half a million inhabitants in the Dhar district. The success of this unique experiment has shown that mass empowerment can only come through such innovative experiments. The potential of such a project has been recognized internationally for introducing a new paradigm in the use of IT in bringing about social transformation.

[26] Source: Planning Commission (2001).

Karnataka

Reliance, in collaboration with the government of the state of Karnataka, has decided to establish 7,500 *mahiti* centres (information kiosks) of which 745 centres would be used for maintaining a data base of land records and other documents, which could be accessed for a nominal fee. It is estimated that around six million farmers will get benefited. Another experiment worth mentioning is the initiative in floriculture industry at Tumkur. The industry regularly participates in the international bid for exporting tulip flowers to the Amsterdam and other European markets on a regular basis making full use of IT. The flowers are dispatched to the respective destinations at the right time.

Tamil Nadu

A comprehensive database of land records in various parts of the state has been created. A set of application software for use at *taluk* and district levels has been developed, tested, finalized and has been installed in 50 taluk offices. Further, two pilot projects are running in four *taluks* of the state for digitization of the cadastral maps as the first step towards creating data base of digitized land maps. The state has also implemented application software for monitoring development projects at the block level and most of the district headquarters through video conferencing facility. The thrust of these projects is to make the citizen interface with the government both pleasant and purposeful.

Uttar Pradesh

Kashika telecom has established in eastern UP low-cost e-mail *dhabas* financed through bank loans. Computer education programmes are also available through these Kiosks. These Kiosks also help local farmers regarding information about paddy prices and land records to a limited extent.

A2 Private sector initiatives

Zee Interactive Learning Systems project provides interactive learning through blending, satellite, video, the internet multimedia and cable network. The project will have several ZED points (kiosks) and it involves launching of an exclusive project for educating rural children. The teaching will be interactive through the combined use of TV and PC. The aim is to construct ‘knowledge building communities’ at an affordable cost even to rural population, where students and faculty around the globe can collaborate.

Intel Corporation has taken the initiative to set up teacher training laboratories to train 100,000 schoolteachers in India. The company also plans to participate on a joint project with the department of Education to develop an effective program for computer aided learning in schools. It also envisages operating ‘cyber school on wheels’ project especially targeted towards educating rural masses.

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