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INFORMATION TECHNOLOGY AND INDIA'S ECONOMIC DEVELOPMENT.

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Information Technology and India's Economic Development*

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Abstract

This paper discusses the possibilities for broad-based IT-led economic growth in India, including increasing value-added, using better telecom links to capture more benefits domestically through offshore development for developed country firms, greater spillovers to the local economy, broadening the IT industry with production of telecom access devices, improving the functioning of the economy through a more extensive and denser communications network, and improving governance. We also examine the policy environment, arguing that government policy is better focused on removing labor market distortions and infrastructure constraints, rather than providing output or export subsidies to the software industry.

Keywords: information technology, software, complementarities, telecommunications
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1. Introduction

The success of India's software industry on the global stage has captured the imagination of Indians in a way that only cricket and hockey successes could in the past. Indians (or people of Indian origin) have become leaders of, as well as contributors to, the information technology (IT) revolution in the United States, reinforcing the impression that India is world class in IT. At the same time, India remains an extremely poor country, with levels of human development for the masses that put it in the same league as sub-Saharan Africa. From this perspective, India's IT success represents the emergence of another elite enclave, with increased inequality the result.

In this paper, we examine the question of whether IT can do more than fuel an enclave-based export boom. Can IT contribute to India's economic development in a broader, more fundamental way? What are the potential mechanisms whereby this can occur? What is the likelihood of IT accelerating India's growth, and what are the potential roadblocks or bottlenecks where government policy can make a difference between success and failure? This paper assumes a basic familiarity with the general structure and performance of the Indian economy, and the economic reform process that has been taking place through the last decade or more. In Section 2, therefore, we begin our analysis directly by examining the performance of India's IT sector, discussing the role of software versus hardware, the growth pattern of the software industry and software exports, the rapid emergence of IT-enabled services, and the role of the domestic market.

Section 3 turns to a consideration of the resource needs of the IT sector, and possible constraints and bottlenecks. These include the supply of IT-skilled labor to support future growth, telecommunications and other aspects of infrastructure, and possible financial constraints. Section 4 uses a range of economic ideas to map out the possibilities for broad-based IT-led development, going beyond the IT sector. We draw on recent analyses of the process of economic development that emphasize factors such as innovation, complementarities in technologies and in demand, and pecuniary externalities. In terms of the mechanisms for development, we discuss examples such as increasing value-added, using better telecom links to capture more benefits domestically through offshore development for industrial country firms, greater spillovers to the local economy, broadening the IT industry with production of telecom access devices, improving the functioning of the economy through a more extensive and denser communications network, and improving governance at all levels.

Section 5 examines the policy environment, which interacts with resource availability, in the light of broader developmental possibilities. Issues raised here include the provision of education, labor market distortions, infrastructure development in areas such as telecommunications, and tax and subsidy policies. Section 6 provides a summary conclusion, with an assessment of possibilities and recommendations for policy.

2. The IT Sector

Information technology essentially refers to the digital processing, storage and communication of information of all kinds[1]. Therefore, IT can potentially be used in every sector of the economy.[2] The true impact of IT on growth and productivity continues to be a matter of debate, even in the United States, which has been the leader and largest adopter of IT.[3] However, there is no doubt that the IT sector has been a dynamic one in many developed countries, and India has stood out as a developing country where IT, in the guise of software exports, has grown dramatically, despite the country's relatively low level of income and development. An example of IT's broader impact comes from the case of so-called IT-enabled services, a broad category covering many different kinds of data processing and voice interactions that use some IT infrastructure as inputs, but do not necessarily involve the production of IT outputs. India's figures for the size of the IT sector typically include such services, and they will be discussed in this section. We begin with a review of the overall industry size, then discuss software versus hardware, exports versus domestic sales, and, finally, IT-enabled services.

Table 1: India's GDP and IT Sector

Year	GDP at current prices (Rs. Billion)	IT sector (Rs. Billion)	IT sector (US $ Billion)
1994-95	9,170	63	2.0
1995-96	10,732	99	2.9
1996-97	12,435	137	3.8
1997-98	13,900	187	5.0
1998-99	16,160	248	6.1
1999-00	17,865	371	8.7
2000-01	19,895	554	12.2

Sources: GDP: www.adb.org, IT sector: www.nasscom.org/it_industry/indic_statistics.asp

[1] A popular alternative is ICT, for information and communications technology: the World Bank, for example, favors this term.
[2] In this sense, it is an exemplar of what is called a general-purpose technology in economic modeling of growth processes. See Helpman (1998) and Kapur and Ramamurti (2001). We take up this idea in detail in section 4.
[3] To give a sampling of research in the US, David (2000) emphasizes the lag with which any new technology affects productivity; Gordon (2000) offers a skeptical view of the impact of IT on productivity, arguing that the empirical evidence indicates that the impact is narrow and limited; Jorgenson, in the most comprehensive analysis, finds that IT has contributed significantly to total factor productivity growth (TFPG) in the US. Of course, higher TFPG implies higher overall growth, *ceteris paribus*.

Table 1 provides statistics on the overall size of GDP, and on the size of the IT industry, in billions of current Rupees. The IT industry figures are not necessarily as accurate as the GDP figures, and they are based on revenues rather than value added, so they are not conceptually directly comparable. Nevertheless, Table 1 gives an idea of the growing importance of the IT sector in India's economy. The IT sector grew over this six-year period by a factor of nine, whereas GDP slightly more than doubled in the same period. Table 1 also gives dollar equivalents for the IT sector figures: these reflect the changing exchange rate over the period, though again there appear to be some discrepancies. With the Rupee falling against the US dollar over this period, the dollar value of the IT sector grew by a factor of six.

Even with its spectacular growth, India's IT sector in 2000-01 was less than 3% of GDP (even if one treats all sales as value added), suggesting that there is considerable room for further growth. For example, if India's nominal GDP were to double over the six years subsequent to 2000-01, while the IT sector were to increase by a factor of six, and if we assume that value added is about two thirds of total sales, the resulting ratio of the IT sector to GDP would be in the range of 8%, or not dissimilar to that in the US today. This calculation assumes slower growth than in the 1999 McKinsey-NASSCOM projections, but may be a more likely figure.

Software vs. Hardware

The basic distinction in IT is between hardware and software. The former refers, of course, to the physical components of processors, storage devices and communications devices. The latter refers to the instructions that govern the flow and processing of information in digital form, within and between hardware devices and components. The design of hardware actually involves the development and use of appropriate software code, so there are definite overlaps in the two categories. It is also possible to substitute software for hardware in the basic design of circuits. The actual production of hardware is classified within the manufacturing sector, and is more distinct from the development of software. Profitably manufacturing semiconductors and other sophisticated hardware components typically requires infrastructure, large-scale investments in capacity, and accumulated experience that India does not possess, and is not in a position to acquire easily. India's development path, despite its emphasis on import-substituting industrialization, has not supported the growth of a robust, world-class manufacturing industry, such as has arisen in many East Asian countries.

Nevertheless, India does perform many hardware assembly tasks internally, almost entirely for the domestic market. Components in such cases typically come from East and Southeast Asia. The ability to organize this aspect of production may be the basis for further development of hardware capabilities. Several East Asian countries also began as mainly assemblers of sophisticated components produced elsewhere, and extended their presence in the value chain backward as they learned by doing. While being late to the game may make entry more difficult, the fact that manufacturing of components becomes increasingly standardized, and the cost of these components falls, works in favor of late entrants. For example, the production of most memory chips has become commoditized, and moved to developing countries, where 20 years ago it was the core of Intel's business.

The example of firms like Dell and Cisco may also be useful to keep in mind when evaluating the hardware industry in India. Dell outsources most, if not all, of its component manufacturing. It is, in fact, an extremely sophisticated assembler. Its value creation is based on organizing this assembly as efficiently as possible, doing so on demand, and keeping its inventories absolutely minimal. Strong customer service plus management of communications and logistics at both ends of the value chain are also keys to Dell's success. Dell's positioning to take advantage of strengths in infrastructure and closeness to a growing customer market is an important lesson for India. The point here, which we shall further develop subsequently in this paper, is that a hardware industry in India is feasible, building on India's experience in assembly, but it will require significant improvements in infrastructure, and careful attention to market needs. Our earlier discussion of hardware design is relevant here, since this is an area where software expertise matters more, and manufacturing infrastructure does not. Therefore hardware design may be a promising area for Indian IT. Table 2 gives some basic statistics on the decomposition of India's IT sector.

Table 2: India's IT Sector Decomposition (Rs. Billion)

Year	Hardware	Software	Other*	Domestic**	Export**
1994-95	23.8	26.1	13.6	34.6	21.1
1995-96	36.8	41.9	20.2	59.0	26.6
1996-97	48.1	63.1	25.8	68.4	49.8
1997-98	52.4	100.4	33.8	88.5	73.4
1998-99	42.5	158.9	36.4	105.4	110.3
1999-00	65.7	243.5	61.6	152.7	176.3

Sources: www.nasscom.org/it_industry/indic_statistics.asp
Notes: *Includes peripherals, training, maintenance and networking; **Hardware, software, peripherals.

India's software industry is more robust than its hardware industry, at least in certain areas. While selling packaged software to consumer (and most business) markets requires economies of scale and scope, as well as marketing and customer support muscle, project-oriented components of software development do not do so, to quite the same degree. The software development and use life cycle includes analysis and specification of requirements, design, coding, testing, installation, maintenance and support. Many of these activities, particularly coding and testing, involve *relatively* routine IT skills that India's workforce has in large absolute numbers (though small relative to the total population).

The existence of the Indian Institutes of Technology (IITs), the ubiquity of Unix in academic environments, and the relatively low infrastructure demands of learning to use and create software all worked in India's favor on the supply side. The use of English in India's higher education system, the increase in the use of Unix and related operating systems due to the explosion of the Internet, and the large number of Y2K-related projects in the late 1990s all contributed to demand for India's software industry services, in addition to the general growth in

IT in the 1990s. Much of this demand came from abroad, as we discuss in the next subsection. However, the software industry's domestic revenues also grew rapidly in the last few years, at over 30% per annum, on average.

Despite the even faster growth of software exports, domestic software revenue still represents about 30% of software industry gross receipts. The National Association of Software and Services Companies (NASSCOM) projects domestic sales to grow substantially faster than export sales in the next decade, enough to make domestic sales over 50% of the industry's sales, and this seems to borne out by recent growth in domestic software (31% annual growth from 1998-99 to 2000-01, NASSCOM, 2002a, b), and IT overall (42% growth in 1999-00). Much of this growth was driven by demand from state governments, which have been introducing e-governance initiatives. The second largest sector in terms of domestic IT demand is financial services. In the domestic market, products and packages make up almost half of revenues, with projects accounting for over a quarter, while professional services, support and maintenance, IT-enabled services and training each make up less than 10% (Singh 2002). This pattern is quite different from that of exports, as we discuss below.

Software Exports

India's software exports went from a few million dollars in the 1980s, to over a billion dollars by 1995-96, and $6.2 billion in 2000-01. Despite the global slowdown, software and services exports exceeded the 2000-01 figure by 31% in dollar terms, crossing $8 billion.[4] While growth has slowed from the earlier 50% rate, the dollar increases are as big. While the NASSCOM-McKinsey target of $50 billion in software export revenue by 2008 may be overoptimistic,[5] the resilience of software exports in a difficult economic climate has proved pessimists wrong.

The pattern of activities that generates software export revenue is somewhat different from the sources of domestic revenue. In particular, professional services accounted for 44% of export revenue in 1998-99, followed by projects at 36%. Products and packages were only 8% of the total compared to nearly half for domestic revenue. Desai (2000) suggests that the difference in the patterns of domestic and export sales is overstated, because domestic sales of packages are by resellers of packaged software licensed from foreign software vendors. However, this appears to be changing, as Indian firms develop packages for the home market in areas such as financial services.

Coding and testing appear to form a significant proportion of the skills used in the Indian software industry. Some have expressed concern[6] that the Indian software industry is "programmer heavy", and therefore unable to move up to higher value-added segments of software. Related issues that reinforce these concerns are the brain drain of the most talented or experienced IT people, the lack of sufficient managerial skills for more sophisticated contract work, and the lack of domestic spillovers from the "body shopping" of programmers for onsite

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[4] Data from Electronics and Computer Software Export Promotion Council, reported in Business Standard, April 9, 2002. Hardware export figures, while much smaller, also showed robust growth.

[5] See http://www.nasscom.org/it_industry/sw_export.asp.

[6] See, for example, Heeks (1996, 1998) and Desai (2000).

work in developed countries. Again, the latest trends suggest that Indian firms have begun to overcome these roadblocks.[7]

Indicators of the strength of India's software export capabilities include the depth of its base, and the breadth of its global reach. There are over 2,000 Indian software exporters, and while only the top five (TCS, Infosys, Wipro, Satyam and HCL) are – or are approaching the status of – global brands, they together account for only about 30% of software exports.[8] While the United States remains by far the largest market for India's software exports, its share of India's software exports has fallen slightly, to 62%, with Europe coming in at 24%, and Japan and the rest of the world accounting for the remaining 14%.[9] Individual firms and organizations such as NASSCOM have shown themselves to be adept at targeting markets with substantial growth potential, such as Germany, and the reputations built in exporting to the US are proving important.[10]

IT-Enabled Services

IT-enabled services are not necessarily related to the production of software or IT in general, but use IT to make the provision of services possible. Customer call centers are one example, where Indians have been training to speak with American accents, in order to deal with customer queries from the US. Accounting services are a second example. Yet another, more long-standing market segment is that of medical transcription. NASSCOM provides a categorization of 10 different types of IT-enabled services (Table 3), varying widely in terms of skills required and value added.[11] The ten categories overlap to some extent, but they give a good idea of the scope of the industry.

Table 3: IT-Enabled Services Types

- Customer Interaction Services
- Business Process Outsourcing / Management; Back Office Operations
- Insurance Claims Processing
- Medical Transcription
- Legal Databases
- Digital Content
- Online Education
- Data Digitization / GIS
- Payroll / HR Services
- Web site Services

[7] See, for example, Tschang (2001) and Kapur (2002).
[8] These figures are taken or constructed from http://www.nasscom.org/it_industry/top20_exporters.asp. See also http://www.nasscom.org/it_industry/top20_sw_cos.asp and http://www.nasscom.org/it_industry/sw_export.asp.
[9] The figures are from http://www.nasscom.org/it_industry/export_destinations.asp Similar figures are given by *Dataquest* (2001), Heeks (1998) and Desai (2000).
[10] For example, see http://www.tcs.com/news/tcs_media/htdocs/sh01/nov01_FT_article.htm
[11] Raman Roy, CEO of Spectramind, suggests five categories of 'teleworking': data entry and conversion, rule-set processing, problem-solving, direct customer interaction and expert 'knowledge services', ranked in terms of increasing sophistication and value added. See *The Economist* (2001), p. 60.

Source: http://www.nasscom.org/it_industry/spectrum.asp

In terms of potential, the first category in Table 3 is projected to be reach $60 billion worldwide in 2003. Other categories may be similar in size or smaller, but Indian industry is making inroads into all of them. According to NASSCOM, revenues from IT-enabled services in India in 2000-01 were over $ 800 million, up 70% from the previous year. Customer interaction services were the highest growing segment within this sector with over 100% growth in 2000-01, and generating 20% of the sectors' revenue. Back office operations' revenues grew over 40% in the same period, and provided a third of the sector's revenues. NASSCOM projects IT enabled services to generate revenues of $ 17 billion and provide employment for 1.1 million people by 2010, while a report submitted to the Indian government's Electronics and Computer Software Export Promotion Council, sees IT-enabled services exports growing from their estimate of $264 million in 2000 to over $4 billion in 2005.[12].

The rapid growth of the sector illustrates that many of the early problems have been overcome. These included firms that were too small to market to or deal directly with clients, and to make investments in adequate training and infrastructure.[13] Success has generated attention, and NASSCOM, the government and others are working on providing incentives, venture funding, training and infrastructure. Good communications links are obviously important for the success of IT-enabled services. An additional bottleneck in the past may have been the lack of managerial and marketing skills, and of reputations for quality. Part of the solution includes the import of such skills by multinationals such as GE and Citigroup shifting some of their back office operations to India. There is no doubt that there have been positive reputational and resource spillovers from the software export sector to IT-enabled services.[14]

3. Resource Considerations

As in any industry, the availability of adequate supplies of inputs is critical for growth. Much of the caution about the prospects for India's IT industry has been focused on potential bottlenecks in the supply of skills, and the quality of the infrastructure. We add financial constraints to this combination, and discuss each of these briefly.

Supply of Skills

A major reason for the success of India's software industry is the large supply of labor with some IT skills. India graduates perhaps about 125,000 engineers a year, second only to the US worldwide.[15] However, not all these engineers go into the IT industry, and not all IT professionals have engineering or computer science qualifications – this being true of the US as

[12] See *The Economist* (2001).
[13] See *DQ Week* (2001).
[14] See Kapur and Ramamurti (2001) for a more detailed argument, including the role of Indians with experience of working in Silicon Valley and other global IT centers.
[15] See *Business Week* (2001). However, Aggarwal (2001) gives a substantially lower figure of 55,000 engineering graduates annually, excluding private institutes and Masters of Computer Applications (MCA). Arora and Arunachalam (2000) estimate an overall figure, including MCAs and graduates of informal training institutes, of close to 140,000 per annum. Kapur (2002) quotes World Bank estimates of 160,000 graduates and diploma holders in engineering and technology in the late 1990s. See also Arora et al (2001a, 2001b) and Saxenian (2001).

well.[16] India's stock of IT professionals is estimated at over 400,000,[17] so that IT industry revenues per IT professional (assuming that all of them work in the industry, which is unlikely) are about $30,000.[18] Government targets and others' optimistic projections imply IT industry revenues will increase by a factor of 15. The breakdown of this growth could be something like a doubling in revenue per IT professional, and therefore almost an eightfold increase in numbers. However, to the extent that much of this future growth will come in IT-enabled services, the additional employment may come in areas where different, easier-to-acquire skills are needed.

Whether growth comes in revenue per employee or number of workers, there are implications for training. Increasing revenue per IT professional requires improvements in managerial and marketing skills[19], as well as the production of more highly trained IT people. Training more people in IT requires investments to increase the capacity of this component of the higher education sector. This is a thorny problem, given the poor state of India's higher education system. Even at the elite IITs, faculty are poorly paid relative to industry, and the physical infrastructure has deteriorated from lack of investment. Increases in government expenditure to fix these problems are difficult in an environment of large budget deficits and long-term neglect of basic education. Interestingly, the task of training workers for IT-enabled services such as call centers is much easier, since the universities produce large numbers of graduates with some familiarity with the English language and Western culture. In all areas of IT and related services, however, increased private and public investment has occurred.[20] One potential problem is that of maintaining standards and quality, but industry-determined certifications exist, and reputations can be established quite quickly in practice in a competitive environment. IT industry investment itself plays a role, since the industry has a strong interest in growing the available supply of IT professionals.[21]

A further problem besides sheer numbers is the issue of level of training, and even the IITs are hard pressed to provide postgraduate education comparable to what is available in the US. Here, the brain drain, initially severe, can be beneficial, as the current slowdown in the US sends back thousands of Indian IT professionals with valuable training and experience.[22] Desai (2000) uses this issue to suggest that India may actually be better off by continuing to specialize in the lower end of the market, for coding and testing, as well as in IT-enabled services, at least in the next few years, but this argument may miss the point that sustained success requires the simultaneous use of workers with many complementary skills at different levels.[23] Which route

[16] See Arora *et al* (2000), as well as Heeks (1996) and Desai (2000) for further discussion.
[17] Data from NASSCOM, reported in CCI Business Bulletin, February 23-March 1, 2002, http://www.ccindia.com/bulletin.html.
[18] This uses the revenue figure from Table 1, for the Indian IT industry, and is overstated to the extent that it excludes some types of employees. Arora *et al* (2001a) construct a lower estimate of $15,600 for 1998-99 (their Table 1).
[19] The implication is that changes in the product-service mix toward that involving higher value-added tasks would be associated with these improvements, resulting in increased productivity.
[20] See Arora and Athreye (2002) and Kapur (2002) and the references therein. The former paper emphasizes the regional concentration of engineering colleges in India.
[21] IT industry figures include over $400 million of IT training revenues, for example.
[22] Kapur (2002) argues that this process has begun and been important in India, though perhaps not to the same extent as in countries like Taiwan (Saxenian, 2000).
[23] This idea has been formalized in the 'O-ring' theory of production, developed by Kremer (1993). See also Basu (1997), Chapter 2.

is most profitable is best left up to the players, with the government's role being to avoid excessive policy distortions that create imbalances across different segments within the IT sector. The last two years have suggested that the education industry can respond quite well to a situation where the benefits of certain kinds of education are clear and immediate.

Infrastructure

Government failure in the realm of infrastructure provision has been a major characteristic of Indian economic development. Of the various infrastructure constraints, probably that of electric power is the most fundamental, and the most difficult one to tackle. We will not address it here, because the subject is too large, and it is not central to our analysis, though electric power is clearly necessary for an IT industry.[24] Other infrastructure constraints, such as water, roads and ports, have served as greater bottlenecks for manufacturing. In fact, one of the reasons software exports were able to take off in India was their lack of dependence on these latter kinds of infrastructure. The development of software parks by eager governments has helped to relax physical infrastructure constraints where they did exist. However, a severe potential constraint is the poor overall state of India's telecom infrastructure. The benefits of well-functioning telecommunications are much broader than just in IT, but the Internet and the associated IT boom have made India's telecoms bottleneck a greater concern. At the same time, rapid technological change and the success of India's IT industry are together leading to solutions.

The basic technological driving force for telecoms is the IT revolution itself. The ability to digitally encode all kinds of information, whether voice, data, or video, makes it possible to send all this information over a single network with digital capabilities. This combined network may include copper wires, fiber-optic cables, and wireless transmission. This is the essence of "convergence". The implication of convergence is that telecoms are receiving more attention than in the past. While India began to encourage the setting up of Public Call Offices (PCOs) throughout the country in the 1980s, teledensity remains very low, between 2 and 4 per hundred (well below other developing countries such as China). The quality of lines and exchanges is poor, and most telecoms remained a government monopoly until very recently, failing to follow quickly on the path of liberalization begun in 1991. It has been the rise of India's software industry that has focused attention on the benefits and feasibility of dramatic change in the telecoms sector.

The software industry uses international data links for accessing clients' hardware, communicating by e-mail, exchanging files among joint development teams, and carrying out remote diagnosis and maintenance work.[25] IT-enabled services use voice lines for call centers, and data lines for transmitting electronic files back and forth. Internet-based media companies also require data links. While all economic activity requires good communications infrastructure, the rapid rise of the Internet has increased such needs.

International links are an obvious area for improvement if the Indian software industry is to realize its lofty growth projections. Belated, but now rapid, deregulation is likely to remove

[24] See Dossani and Crow (2001) for an excellent survey and analysis of power sector reform in India.
[25] See Heeks (1996, 1998).

international bandwidth constraints.[26] Several problem areas remain, which will require attention. These include the system of interconnect charges, licensing fees and deposit requirements for entry, restrictions on franchising, bandwidth allocations, and so on. The challenge of building a financially viable, robust and extensive telecoms infrastructure still exists.[27] The tendency of government regulators still appears to be to over regulate, one prominent example being the requirement for new private telecoms to meet old-style quotas for installing village telephones, without adequate regard to financial viability.

With appropriate policy adjustments, technological progress, including domestic innovation, may be an important factor in removing current telecoms infrastructure constraints. Ashok Jhunjhunwala (footnote 27) gives the example of cable services in India, which are priced at $2 to $4 per month, and have 35-40 million subscribers. At this kind of price point, however, a rural telecoms operator in India cannot recover set-up costs for access, which are about $800 using conventional technologies. The goal of innovations by Jhunjhunwala's team, therefore, has been to bring the cost of combined Internet and voice access down to $200. The latter figure would make access affordable to 50% of Indian households at current income levels. Without such innovations, government targets of increasing India's teledensity fourfold (from 4 to 15 per hundred), or Internet access tenfold are empty rhetoric.

The bottom line is that bringing down the cost of access through innovation targeted at the domestic market is a critical component of any dramatic increase in telecoms connectivity in India. Economically combining Internet and voice access also has the benefit of increasing the value of connecting to the network. The benefits accrue not just to the poor, but also to the tens of millions of lower middle class households who are currently outside the affordability radius. A denser domestic network not only increases the value of international network links, but it also provides opportunities for increasing the rate of training of IT personnel. Finally, the development of an indigenous hardware industry for low-cost access devices and network components has the potential to fill in gaps in India's IT capabilities on the manufacturing front.[28]

Financial Constraints

A striking feature of the Indian economy pre-reform was its inefficient use of capital. Relatively high savings rates were associated with relatively low growth rates. Financial sector reform in India has focused on making the country's organized capital markets more efficient. Simple institutional improvements such as electronic trading and settlement, guidelines for corporate governance, and so on, have been introduced. However, the nature of the financial system overall still involves 'financial repression', with the banking sector and a large number of other financial institutions being subject to parking of government and state enterprise deficits and to directed lending.[29] These problems mean that substantial inefficiencies remain in the

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[26] See Singh (2002) for further details and additional references.
[27] Two sources for tracking policy issues and broader concerns are www.trai.gov.in, the website of the Telecoms Regulatory Authority of India, and http://www.tenet.res.in/Papers/papers.html, which features the work of the IIT-Chennai group headed by Ashok Jhunjhunwala. The most recent of these is www.tenet.res.in/Papers/techolo.html. See also Jhunjhunwala (2000).
[28] This does not mean trying to do it all in-house: again Dell is a useful example to bear in mind.
[29] See Singh and Srinivasan (2002) for a more detailed discussion in the context of federalism and reform.

financial system. This has negative implications for industry overall[30], but particularly for a fast-growing sector such as IT.

Clearly, broader reform of the financial sector is required. While such reform has, as noted, been taking place in areas such as the functioning of Indian stock markets, corporate governance, regulation of banking, and methods of central government borrowing, the constraints imposed by the web of government-controlled financial institutions and their 'bad' loans to the public sector are a severe hurdle to further reform. For IT start-ups, venture capital has been extremely important, and this should be the case for India also. While the initial lack of a venture capital industry in India may have been positive, in the sense that the policies to create one could be considered from scratch, efforts to do so have tangled with existing mazes of financial regulations and legal restrictions, including tax and corporate law. An important beginning was made by a committee on venture capital appointed by the Securities and Exchange Board of India (SEBI), India's chief financial regulator. The committee's report was adopted by SEBI in June 2000, but many of the changes required are beyond SEBI's jurisdiction.[31]

Despite policy hurdles, which are still receiving attention, venture capital in India is starting to take off. A government sponsored VC fund, the National Venture Fund for Software and IT industry (NFSIT), was launched in December 1999. States such as Andhra Pradesh, Karnataka, Delhi, Kerala, Gujarat, and Tamil Nadu have also set up their own venture funds. It is not clear how effective government-sponsored funds can be, since venture capital involves high risks that are not normally associated with government activities, and government intervention may be subject to other incentive problems. Putting aside these issues, it is true that venture capital funding in India's IT sector increased from $80 million in 1997-98 to $500 million just two years later.[32] If a venture capital industry can flourish, and stock market institutions can continue to develop, the growth of India's IT sector can be fueled, but the problems of the rest of the financial sector still cast a shadow.

4. IT and Development

The case for IT as an engine of growth and development must mainly rest on standard economic criteria, such as comparative advantage, complementarities, and the dynamics of the global economy. The IT sector can be an important source of growth for India if the country has a comparative advantage in providing certain kinds of IT-related products and services, if the global demand for these products and services is likely to grow rapidly, and if the growth of the sector has positive spillover benefits to the rest of the domestic economy. The first two of these conditions seem to be well established, though they merit some discussion of future possibilities, particularly with respect to the reasons for and the dynamics of India's comparative advantage in this sector. One of the most interesting issues, which we wish to emphasize here, is the third

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[30] It is arguable that the problem of low growth in India's manufacturing is substantially attributable to difficulties in financing investment.

[31] Important overviews of the issues are in Dossani and Saez (2000) and Dossani and Kenney (2001). Rafiq Dossani was one of the members of the SEBI committee.

[32] The data, and other information on India's VC environment, can be found at http://www.nasscom.org/business_in_india/vc_scenario.asp.

condition, of spillover benefits. This is the area where the IT sector may be special, and not just another export enclave. Furthermore, IT may have a role to play in broader human development, beyond just economic growth. This is a contentious issue, with sharply opposing views expressed. We will proceed in this section as follows. First, we outline some theoretical ideas that are relevant for thinking about the role of IT in growth, and which will inform our consideration of different aspects of this role. Thus, we sequentially examine issues of comparative advantage in software and services, the development of a domestic market, spillovers to the economy as a whole, and the potential impact on governance.

IT and Growth Theories

The starting point for considering the role of IT in development has to be theories of growth that give endogenous innovation a central role. The ingredients of these models typically include differentiated capital inputs, monopolistic competition, production of new inputs through R&D, and ultimately economy-wide increasing returns that allow sustained growth to occur. Hence these models shift away from the exclusive focus on capital accumulation that characterized the neoclassical growth model and the core of Indian post-independence economic policy. The work of Grossman and Helpman (1991) and Rivera-Batiz and Romer (1991a,b) incorporates international trade and the evolution of comparative advantage into endogenous growth models. In these analyses, the economy is typically divided into manufacturing, R&D and traditional sectors, so IT does not necessarily fit neatly into any one category. Design and development of software may have characteristics of R&D, while IT-enabled services are more like manufacturing in their use of established techniques for production. The general message of these models, however, is that externalities associated with monopolistic competition may give policy a role in influencing the evolution of comparative advantage.[33]

The general models of endogenous growth leave open the issue of what makes IT special. Here, the concept of general-purpose technologies (GPTs) seems very useful. The idea of GPTs was introduced by Bresnahan and Trajtenberg (1995), who define them in terms of having three key characteristics: pervasiveness, technological dynamism and innovational complementarities.[34] Examples of GPTs include writing and printing (both earlier advances in IT), modern digital electronic IT, steam and electricity (both advances in power delivery systems) and synthetic materials. Helpman and Trajtenberg (1998a, 1998b) have developed a model of growth led by GPTs, in which sustained growth comes from the periodic, exogenous introduction of new GPTs. Other mechanisms that would give endogenous growth are ruled out, but otherwise, the framework consisting of endogenous R&D, monopolistic competition and the introduction of new intermediate inputs as the mechanism of growth is similar to endogenous growth models. In these models, any GPT has similar abstract effects. Dudley (1999), using a different theoretical approach, but the same overall idea, makes a case for information and communication technology as a particularly influential or fundamental GPT. He constructs a simple model of innovation working through falling costs of communication in networks.

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[33] Other, more recent treatments of endogenous growth and trade that may be useful in thinking about IT in India include Basu and Weil (1998) and Chuang (1998).

[34] See Lipsey, *et al* (1998) for a detailed survey and examination of the concept, as well as the other pieces in Helpman (1998). The idea of complementarities is discussed in greater detail below: it is closely related to the older idea of linkages: see Basu (1997) and Ray (1998) for references and discussion.

We can say a little more about the characteristics of GPTs in the context of IT in particular. Pervasiveness seems to be potentially a natural property of IT. In the Indian context, doubts are centered on issues of cost and access. We have touched on those briefly earlier in the paper, and will return to them later in this section. Table 4, however, illustrates the important positive trends that support pervasiveness. Technological dynamism refers to the potential for sustained innovation that come with new GPTs, and is again illustrated by the dramatic fall in costs shown in Table 4. Complementarities of GPTs are vertical complementarities, because GPTs spur innovation and lower manufacturing costs in downstream sectors, with positive feedback effects to the GPT itself. There are also horizontal complementarities, since the downstream sectors may face a coordination problem in expanding sufficiently to encourage the improvement of the GPT. Note that international trade with a more advanced country may be one way to overcome some of these externality problems. That seems to the lesson of India's IT sector development.

Table 4: Falling Costs of Computing ($)

Costs of computing	1970	1999
1 Mhz of processing power	7,601	0.17
1 megabit of storage	5,257	0.17
1 trillion bits sent	150,000	0.12

Source: Pam Woodall, "The New Economy: Survey," *The Economist*, September 23, 2000, p. 6, Chart 1.

The importance of complementarities in understanding growth processes has been described in most detail by Matsuyama (1995, see also Ciccone and Matsuyama, 1996, Basu, 1997, and the references therein). Matsuyama makes three useful observations. The first is the identification of the differing roles played by horizontal and vertical complementarities, such as we discussed in the previous paragraph. The second is the difference between technological complementarities, emphasized by writers such as Kremer (1993) and Milgrom, Qian and Roberts (1991) and the demand-based complementarities and pecuniary externalities that drive models such as those of Matsuyama and his co-authors. The third point is the difference between the effects of history and of expectations in affecting equilibrium outcomes and growth. Either or both may work against development and growth, by preventing coordinated movement out of a 'bad' equilibrium.

Matsuyama examines a range of models, and shows how growth may be arrested or sustained, and what kinds of inefficiencies might arise. In particular, the externalities generated by the structure of complementarities can lead to inefficiencies that are best characterized as coordination failures. This set of problems also arises in the GPT models of Helpman and Trajtenberg, discussed above. Without going into details, we suggest that this literature has some relevance for thinking about the role of IT in Indian development. In particular, while the success of IT so far may be the result of factors that have to do with initial comparative advantage (see below), the fortuitousness of freedom from government controls (see Kapur, 2002) and integration with the world economy during the boom of the 1990s, the kinds of problems that IT may face in the future, as an engine of growth, have to do with potential coordination failures in providing other inputs along with IT, or in the downstream sectors that use IT. For example, if Indian manufacturing remains moribund because of the government's fiscal problems and their effects on the financial sector, a significant market for India's IT sector may be stifled. We investigate some of these issues in the remainder of this section.

Comparative Advantage

The static theory of international trade is based on comparative advantage, determined by relative factor endowments and/or technology differences. Empirically testing this theory is difficult, since other influences may also be at work. For example, intra-industry trade driven by product differentiation and economies of scale may involve different trade patterns than those based on traditional comparative advantage. However, in the case of software exports, attributing the export boom to comparative advantage seems reasonable.[35] We have noted India's pool of workers with software and language skills that are valued in the international market: they are the source of India's comparative advantage in at least some segments of the software industry. As Kapur (2002) emphasizes, the lack of explicit government restrictions on this sector allowed this comparative advantage to assert itself, whereas manufacturing has not enjoyed the same benefits.

While India missed the boat with respect to the labor-intensive manufactured exports that contributed to the East Asian miracle, it is now in a position to replicate this phenomenon with labor-intensive software services and (even more labor-intensive) IT-enabled services. Even if exports of this nature cannot sustain earlier growth rates, they can make a substantial contribution. For example, 20% growth in a sector that is 5% of the economy adds one percentage point to overall economic growth. In the very short run, therefore, moving up the ladder of value added (or establishing a broader hold on the value chain) may not be a critical issue.

There are two reasons for not stopping here, however. The first is a defensive one: greater automation of software development and the emergence of other low-labor cost sources of competing IT skills may lead to export growth falling or even reversing, as global demand for Indian programming services slows or falls due to automation. The second reason is that it may be possible to do even better. Comparative advantage is not fixed, and countries can move toward producing higher value-added goods and services as they grow, with favorable consequences for long run growth. Applying endogenous growth models is not an automatic proposition, since results are sensitive to assumptions. For example, learning by doing in manufacturing (including software production in this abstract conception) gives different outcomes than the assumption of a separate R&D sector that competes with manufacturing for skilled labor.

[35] Note that, to the extent that India is providing intermediate goods or services in its software exports, the situation is more complex than that of standard trade theory, where only final goods are traded. Monopolistic competition models such as those of Matsuyama are then relevant. For an attempt to calculate India's possible comparative advantage, see Arora and Athreye (2002), Table 4.

If we accept the potential theoretical benefits of moving up the value added ladder, what does this mean in practice for India's software industry? One possibility is offering higher value-added component services, involving design and strategy. Another is offering more complete packages or bundles of services. The latter differs from the former in that a higher management component is included in the package than in particular aspects of software development, even if those require more technical skill. While the global economic slowdown that began in 2001 will hamper these developments in India, there is no reason why Indian software firms cannot enter such markets. The availability of a growing number of professionals with combinations of engineering and management skills will help in this area.[36]

Companies such as TCS have long-standing domestic and developing country consulting expertise, but they may be less suited to compete in a crowded US market than India's new software giants such as Infosys and Wipro, or smaller newcomers.[37] What is the possible competitive advantage of these firms? Certainly lower costs will help, but these may be better used to provide upgraded or broader services, rather than in competing on price alone. In particular, empirical research (Banerjee and Duflo, 2000) shows that reputation effects are quite important for Indian software exporters.[38] Such companies may also develop a strong niche in other developing countries, where lower prices may be more important. A high tech slowdown in the US may actually aid the development of such firms in India, if it leads to some reversal of the brain drain.[39] Otherwise, managerial and high-level technical skills may constrain movement up the value-added ladder. In some cases, including consulting as well as IT-enabled services, multinational firms have relaxed some of the managerial constraints through their own entry, importing managers as well as training local ones.

The Domestic Market

The domestic market for IT products and services is not independent of the export market. The nature of information goods in general is that they involve high fixed costs of production and low marginal costs. While customization and service provision mitigate this property, they do not negate it. Reputation and experience effects, on the other hand, enhance the importance of economies of scale and scope. Hence it is important for Indian software firms to compete simultaneously in domestic and export markets, in order to take advantage of these economies. This is true even though the product-service mix that is being sold in different markets is going to be somewhat different. Since Indian software firms can compete successfully abroad, they should also be able to succeed in their own backyard.[40] In fact, they have advantages in the domestic market, knowing their customers better, and being closer to them. On the other hand, a poor domestic infrastructure, dependence on imported hardware, late mover

[36] Similar considerations apply to IT-enabled services: see footnote 11.
[37] See Das (2001) for a discussion of the Indian e-business consulting market.
[38] Arora et al (2000) and Arora and Athreye (2002) discuss Indian firms' efforts to signal quality by hiring engineers, and through international certification of their processes. They document the positive impact of the latter on value added per employee.
[39] For a description of how Infosys is struggling with the tech slowdown, to "transform itself…from a great code-writer to a one-stop technology services provider", see Bjorhus (2002).
[40] The reverse need not be true, as Arora and Athreye (2002) emphasize in their discussion. They also suggest that there are strong potential spillovers from the IT sector to other services industries, in the form of improved managerial practices that have developed in IT and are easily applied to a range of services.

disadvantages, and lack of economies of scale and learning by doing, can all reduce or eliminate any advantage that Indian software firms might have over foreign competitors.

Two mitigating factors operate on potential disadvantages of Indian firms. First, some of the problems are faced by all firms, irrespective of location: for example, entering the market for desktop operating systems in the face of Microsoft's dominance is difficult, if not impossible, for any firm anywhere in the world. Second, the boundary lines between domestic and foreign can be blurred when multinationals have Indian subsidiaries, particularly for IT or IT-enabled services. In such cases, the effects on the local economy are not that different from when these services are provided by Indian firms. Two differences in the case of multinationals, however, are in profit repatriation and the creation of another brain drain channel, if Indian employees of multinationals can be assigned to other countries.

At the level of business software and software services, therefore, it seems that issues for the domestic market boil down to the same concerns as for export markets. These are availability of the key inputs, namely various types of skilled IT personnel and managerial and marketing skills. Location and ownership are not of direct importance, but are only proxies for whether the IT software and services provider has the right combination of people, knowledge, experience and reputation to compete successfully. Liberalization in general means that all Indian firms face the challenge of building such combinations of assets. The software industry happens to be significant because it has developed independently of India's traditional business houses, and hence mostly free of the bad habits those business groups developed over many decades of operating in noncompetitive environments.

We have focused the discussion so far on software. Hardware may offer additional opportunities to Indian IT firms in the domestic market. In developed countries, the establishment of the PC market took place before the Internet took off. In a good example of complementarities, however, the growth of the Internet has increased the demand for PCs and other access devices. Internet access is probably the most attractive use for many potential consumers of IT in India but Internet penetration may not go far enough with hardware designed for developed countries. Internet kiosks, with shared access, are a solution that has emerged for urban and rural areas, with the start-up cost for a basic kiosk having been brought down to under $2000. While Internet use is beginning to grow rapidly, the number of subscribers remains minuscule, estimated at 1.8 million in December 2000. The main reasons for this backwardness have been the government long-standing monopoly, through VSNL, of the country's Internet gateways, as well as the general poor state and high cost of the telecoms infrastructure. The removal of the VSNL monopoly in 2002 marks a process that began a few years earlier, with NASSCOM lobbying resulting in private ISPs being allowed to set up their own international gateways starting in 2000.

The possibility of designing and building lower-cost access hardware in India may represent an opportunity for the domestic IT industry. While India has tried to develop a domestic hardware industry since the 1980s, it has not succeeded in establishing an industry that is efficient and globally competitive.[41] Much of the problem has lain with lack of scale and infrastructure (as well as general restrictions on Indian business). For components such as

[41] See Hanna (1994), for example, for further details.

sophisticated chips, this will continue to be the case, but, as noted earlier, Indian industry can build on existing capabilities in assembly of standardized components. If some of these components are designed specifically for the broader Indian market, for example to go into low-cost Internet and telecom access devices, as envisaged by the IIT Chennai group (footnote 27), where they are built may not be crucial.[42] We note once more that Dell is a profitable company because it serves targeted markets efficiently, not because it manufactures sophisticated components. Instead, management and infrastructure are the key inputs that are required.

Broad-Based Growth

Are a software industry that serves the domestic market as well as exporting, a hardware industry that can produce low-cost access devices, and IT-enabled services for foreign markets, together enough for broad-based economic growth? The IT sector can directly contribute one or two percentage points to India's growth rate, and this is not insignificant. The possible concern is that it will remain an enclave, exacerbating inequality and doing little for long-run growth. These concerns arise even in developed countries.[43]

The argument for broad positive impacts is based on the kinds of models discussed at the beginning of this section. To the extent that IT can have significant effects on the efficiency of operations in other industries, there are strong complementarities between the IT sector and the rest of the economy. Examples of areas where increased efficiency may be possible include accounting, procurement, inventory management, and production operations.[44] This is, of course, the standard argument in the US for the virtues of the "new economy" based on IT. To connect our observations to the usual e-commerce jargon, we note that these benefits are situated in the B2B arena. The difference for India is that it is starting from a much lower level of IT-adoption, and the potential gains may be higher. In fact, developing countries have the opportunity to leapfrog over older, more expensive approaches such as Electronic Data Interchange, which represent significant legacy investments in countries such as the US. This is also a positive indicator for the future.[45] The argument of Kapur (2002), that India's success in software exports has increased the confidence of Indians, may also be couched in terms of a positive shift in expectations helping to overcome a potential coordination failure.

A general concern with IT-adoption is job loss, and there is certainly the potential that certain kinds of clerical jobs will be eliminated or reduced in numbers. Unions in Indian industries such as banking have opposed "computerization" for this reason. However, the evidence suggests that increases in other kinds of jobs as a result of IT use more than make up for job loss, so that total employment is not a significant issue. In particular, IT-enabled services promise to directly generate employment much more significantly than activities such as software development. This leaves the issue of adjustment costs, and here severance pay rules or

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[42] Another example is the 'Simputer', designed by scientists from the Indian Institute of Science. The portable $200 device will use some parts manufactured in Singapore, Linux-based software developed in India, and run on 3 AAA batteries. See Khoo (2002).
[43] See, for example, Pohjola (1998) and Woodall (2000), as well as the references in footnote 3.
[44] These are all examples of what are also known as "forward linkages", since IT adoption has positive impacts on the operations of a range of industries. The effect of the growth of the IT sector on the provision of technical education would be an example of a "backward linkage". In either case, there is a complementarity at work. Evidence of some forward linkages in the informal IT sector is provided by Kumar (2000).
[45] See also Miller (2001) for a further discussion of the potential for B2B e-commerce in India.

government job adjustment assistance can be more effective and efficient than the current morass of detailed restrictions embodied in India's labor laws. This is why Desai (2000) is right to stress the importance of broader labor law reform if the benefits of growth in India's IT sector are to be fully realized.

In the context of complementarities, it is also important to recognize that these effects are not just in terms of cost savings. IT implementation may enhance the quality of service beyond anything that is feasible through other methods. Furthermore, depending on who the "customers" are, the benefits may accrue to a broad cross-section of the population. Improved efficiency in the stock market as a result of automated trading and settlement may benefit a small section of the population (though the indirect benefits of greater capital market efficiency may be broader). The use of IT in rural banking and micro finance, however, can impact a much broader cross-section of the population. The evidence of pilot schemes such as the SKS InfoTech Smart Card project is encouraging. Handheld computers and smart cards can substantially reduce the costs of making loans, as well as monitoring them. Reducing these transactions costs may turn out to be critical for the scalability and sustainability of micro finance schemes. This and similar examples provide evidence against the enclave view of the IT sector in India.

Of course potential benefits do not necessarily translate into actual ones. Firms and managers can make mistakes in their IT investment decisions, but this is no different from any other kind of investment. In a reasonably competitive industry, with sufficient information available, there is always pressure to make the right decisions, rewards for those who do, and punishments for those who do not. Indian industry must be allowed to follow this model to realize the potential benefits of IT. If it is discouraged from making such investments, the domestic market for Indian IT will not grow, with negative consequences for the IT sector as a whole. This line of thought argues in favor of a sound competition policy, rather than any specific incentives, but we will explore this issue further in the next section.

We have focused mainly on the formal sector in assessing the impact of IT. Even if the growth of the IT has positive spillovers for other industries, this leaves out a substantial portion of the economy. We postpone a discussion of government use of IT to a separate section, but now turn to issues of truly broad-based impacts of IT. There are several possible areas of impact. First, information processing may enhance efficiency in agriculture as well as in manufacturing. While individual farmers cannot make IT investments, agricultural cooperatives can provide the institutional framework that allows farmers to benefit. For example, Chakravarty (2000) gives the example of IT use at milk collection centers in cooperative dairies. This permits faster and safer testing, better quality control, quicker and more accurate payments to farmers, and time savings for farmers in their deliveries. The falling cost of information processing means that such success stories can potentially be widely replicated.

The second impact is in the communication of information. Here the case studies are legion. Farmers and fishermen can receive weather forecasts, market price quotes, advice on farming practices, and specific training. Offers to buy or sell livestock, or other two-way communications are also possible. Some of this information dissemination and exchange is best done through voice media such as fixed or mobile telephones, while other types require the capabilities of the Internet.[46] Some evidence suggests, not surprisingly, that richer farmers and fishermen, as well as middlemen, are faster adopters of such technologies (*The Economist*, 2001a), but falling access costs, through innovations such as those of the IIT Chennai group, should broaden information access and its benefits. Broad-based benefits of IT require broad-based access to the network, as we have discussed earlier.

A third area of impact is closely related to the second, but involves communication of information in a more fundamental way. It is possible that IT-based delivery mechanisms can overcome traditional barriers to widespread delivery of education at all levels. We have noted the importance of IT training itself. However, even basic education may be enhanced by the use of IT. While it may seem paradoxical that delivery of basic education should rely on 'high tech', there is nothing new in this. The radio and television have been very successful distance-education media in the past, and computers and the Internet offer several advantages, in terms of the potential for interactivity, customization and sheer volume of material. Given the poor state of basic education,[47] while improved incentives for teachers and school administrators (either in the public or private sector) will help, technology can play an important complementary and even substitutive role. For example, TARAhaat (a semi-commercial subsidiary of an NGO), in attempting to develop a network of rural Internet centers in a district in Punjab, found that even in the absence of reliable connectivity that would allow access to a variety of Internet-based services, it was able to tap into an underserved market for education in the vernacular medium in the basics of computers and the English language.[48]

The TARAhaat example illustrates several general points. First, in all attempts to introduce IT to rural India in a manner that promotes development, sustainability is a key issue. The TARAhaat franchisee model offers important promise in this regard with respect to incentives and scalability, though there have been difficulties in implementation. Second, the experiment validates the idea that IT costs have come down sufficiently to make rural IT services financially viable. Third, there is the issue of complementarities, both technological and pecuniary. One major roadblock for TARAhaat has been the poor quality of existing telecoms infrastructure. This has severely limited the scope of services that its franchisees could offer,[49] and is an example of government failure. On the other hand, the provision of complementary inputs such as financing and physical infrastructure, through subsidized loans from nationalized banks and the use of local government buildings, have been important in reducing startup as well as operating costs. The most important complementarity emerged when the Punjab Technical University quickly piggybacked on TARAhaat's efforts, enhancing the franchisees' initial financial viability through its own offerings of college-level IT education. This example suggests

[46] Eggleston et al (2002) provide some quantitative evidence for the market efficiency effects of improved communications and information transfer, using data from rural China.

[47] See Dreze and Gazdar, (1997) and the PROBE report (1999). One can also make a case for access to IT based on broader notions of development, such as Sen (1999). That the poorest of the poor can benefit is borne out by instances such as the famous in the hole-in-the-wall-computer (http://www.niitholeinthewall.com/home.htm).

[48] See Kaushik and Singh (2002) for more detail on the TARAhaat effort.

[49] An example from field research in Bathinda district of Punjab in December 2001 illustrates: a farmer told us he had taken computer lessons at the TARAhaat kiosk, bought a home computer, and signed an Internet service contract so that he could exchange email with his brother in Toronto, Canada, as well as look for information on agricultural practices. All three IT-related products and services depended on basic telecom availability. See also Prahalad and Hart (2002).

how the kinds of coordination failure identified in the work of Matsuyama and others may be overcome.

Governance

One area where government can provide indirect support for the IT sector is by boosting the domestic market though its own purchases. Initially, this seemed to follow the pattern of the introduction of PCs in the US, with purchases of sophisticated equipment and software that sat underutilized on desktops. However, falling costs, increased understanding of what IT can do, and greater domestic expertise are starting to take the role of IT in government beyond this beginning.

There are two broad uses of IT for improved government functioning. First, back-office procedures can be made more efficient, so that internal record keeping, flows of information, and tracking of decisions and performance can be improved. Second, when some basic information is stored in digital form, it provides the opportunity for easier access to that information by citizens. The simplest examples are e-mailing requests or complaints, checking regulations on a web page, or printing out forms from the web so that a trip to pick up the forms from a physical office can be avoided. More complicated possibilities are checking actual records, such as land ownership or transactions. Still more complicated are cases where information is submitted electronically by the citizen, for government action or response.

The numerous examples of successful pilot e-governance programs include:

- Computer-aided registration of land deeds and stamp duties in Andhra Pradesh, reducing reliance on brokers and possibilities for corruption
- Computerization of rural local government offices in Andhra Pradesh for delivery of statutory certificates of identity and landholdings, substantially reducing delays[50]
- Computerized checkpoints for local entry taxes in Gujarat, with data automatically sent to a central database, reducing opportunities for local corruption
- Consolidated bill payment sites in Kerala, allowing citizens to pay bills under 17 different categories in one place, from electricity to university fees
- E-mail requests for repairs to basic rural infrastructure such as hand pumps, reducing reliance on erratic visits of government functionaries[51]

As in the broader case of using the Internet for communications and transactions, sustainability of e-governance initiatives is a significant issue. Since governments at all levels are financially strapped, the initial investments and ongoing expenditures for IT-based service delivery may act as a barrier to adoption as well as to long-run sustainability. However, our initial investigations suggest that the franchise model can be successful here. Low-cost rural Internet kiosks, a tiered franchising model, and a suite of basic government access services for which users are willing to pay, are key components of what Drishtee, an outgrowth of the Gyandoot project in Madhya Pradesh, is implementing in several parts of India.[52] Cooperation of local governments and subsidized financing have been important elements for Drishtee, as in

[50] These two examples are from Bhatnagar and Schware (2000), which also provides broader examples, including ones driven more by the efforts of NGOs than governments.
[51] These three examples are from India Today (2000), which also lists several other similar projects.
[52] Further details of Drishtee's efforts are in Kaushik and Singh (2002).

the case of TARAhaat, with the former being obviously critical in the case of Drishtee. It is important to note that once Internet access is available, its benefits are not restricted to e-governance. Individuals can obtain market information, training, job information, advice on farming techniques, and so on, as discussed earlier in this section. This is certainly part of Drishtee's long run model.

Given the poor quality of governance in India, it seems that e-governance initiatives can provide direct benefits to citizens, particularly those who are less well off (the rich in any case hire intermediaries to collect information, make payments, etc.). The preliminary evidence suggests that the use of IT can increase transparency and accountability, simply by requiring information, such as basic complaints, to be logged completely and systematically. In this respect, the use of a non-governmental intermediary such as Drishtee may have advantages over purely internal government initiatives, beyond that of financial viability.

5. Policy Environment

The overall goals of economic policy in India are standard: high growth together with macroeconomic stability and poverty reduction. Balancing these goals is the difficult part. For example, incentives for exports, such as tax breaks, are designed to spur growth, but may adversely affect the government's fiscal deficit. As quantitative controls have receded in importance, such tax-subsidy policies have become more significant policy components. The growth of India's IT sector, and the success of the software industry in particular, has tended to skew policy toward the industry, with targeted incentives being implemented or recommended.

Targeting incentives to the software industry is not necessarily the best method to promote the industry, nor to achieve broader goals of growth and human development. Providing implicit or explicit subsidies to the industry can introduce distortions, and it involves forgoing other uses of funds, given the severe budget constraint that the government faces. Broader promotion of the IT sector also suffers from some of the same problems. Investing heavily in government-sponsored IT-related training is problematic when basic education in India is so poorly provided by the public sector. Policy goals for the IT sector might be better met by focusing on infrastructure provision, enabling the private sector to play a role here as well. The telecoms sector is a case in point.

The historical case for regulation or nationalized provision in telecoms was based on economies of scale, implying that competition would be unstable or inefficient. Technological change has removed this justification in significant portions of the telecoms value chain by lowering fixed costs and adding new technological options, allowing competition to become feasible. Since monopoly may persist in portions of the value chain (i.e., portions of the network), regulation of interconnection charges may still be required, to maintain a level playing field. However, directly managing technology choices and competition is not easily justified on economic grounds. The broad policy goals of promoting competition and innovation in the provision of telecoms infrastructure and services are moving in the right direction.

Broad-based growth of India's IT sector will depend on improving the telecoms infrastructure, and on training enough people for the sector and using them effectively and efficiently. For telecoms, the regulatory framework is crucial, whereas for human resource development and use, the labor laws matter greatly. It may also be noted that laws that directly constrain manufacturing remain on the statute books, and adversely affect areas such as manufacturing or assembling hardware – the problem here is one that still affects Indian manufacturing in general.[53]

In India the regulatory institution for telecoms is the Telecom Regulatory Authority of India (TRAI), which was constituted in 1997 and given greater and clearer authority in 2000.[54] The scope of the TRAI includes establishing quality of service parameters, monitoring compliance, examining technology choices, and so on.[55] It is supposed to establish a level playing field and encourage competition, but it has lacked clear authority precisely where it needs it the most, in setting entry fees and some interconnection charges. Unfortunately, bringing quality of service, technology choice, and universal service obligations (USOs) into the regulatory mix only serve to muddy the waters, and divert attention from the central task of enabling effective competition.

USOs are being built into licensing deals for private service providers. These take the form of quantitative targets for installing rural telephones, and funds created through a form of tax on basic service, to be used for proposed subsidies for rural users. It is not clear that numerical targets have any use at all, when licensing and interconnection fees make it uneconomical for local access providers with lower-cost technology to enter. The distinction between rural users in general, and shared access through Internet kiosks is crucial, but has not been accepted by majority of a TRAI committee that reported on the USO.[56] Our own investigation of the startup problems of TARAhaat and Drishtee suggests that a narrowly targeted subsidy for enabling reliable telecoms access (including solutions such as that of the IIT Chennai group) to Internet kiosks makes most sense.

Desai (2000) examines the problems of labor laws, using the Report of the Subject Group on Knowledge-Based Industries (2000) as his starting point. The report calls for exemption for the IT sector from a broad set of rules relating to labor, including provisions relating to overtime, working conditions, restrictions on contract labor, and dismissal of workers. Interestingly, if IT workers are in short supply, they should be able to negotiate terms that are attractive enough to make the labor laws redundant. Desai suggests that the main function of the labor laws in this sector is to enable government labor inspectors to demand bribes. He also argues for broader reform of labor laws, and rightly points out the potential for distortions if one sector is given an exemption. He also acknowledges the political difficulties of more comprehensive reform. In this case, the IT sector may usefully serve as the thin edge of the wedge that begins cutting down some of the worst problems with India's labor laws, in particular the lack of permitted flexibility in contracting. The development of IT-enabled services will be a litmus test of the changing role of labor laws in India.

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[53] I am grateful to P.D. Kaushik (personal communication) for this point – by his count, there are over 400 central government statutes governing manufacturing, as well as numerous state laws. He also notes that the software industry escaped these constraints partly by not being recognized by the government as an 'industry.'

[54] See Dossani and Manikutty (2000) for details.

[55] See for example, the paper by M.S. Verma, Chairperson of the TRAI (Verma, 2000).

[56] See the report at http://www.trai.gov.in/recom.htm, and especially the two Annexes, which are a dissenting comment by Rakesh Mohan, and the rest of the committee's response. See also Dey (2000) and Singh (2002).

Our examination of the role of the IT sector in broad-based development also suggests the importance of the financial sector. While it seems that large IT firms can rely on retained earnings or the stock and bond markets for growth, startups need a venture capital industry that is just beginning to emerge. As in the case of labor laws, one can argue that the policy environment must be geared toward industry in general, and not just the IT sector. Kapur and Ramamurti (2001), for example, note that industries such as biotech, chemicals, media and entertainment, and construction all require knowledge services that go beyond the basic definition of IT-enabled services. In all these cases, venture capital may be a significant fuel for entrepreneurial energy.

Some of the greatest difficulties face small-scale entrepreneurs, who have been protected by reservations, but who do not necessarily have easy access to the right kinds of help they need as startups. Again, our research on the experience of the local franchisees of TARAhaat and Drishtee suggests that the nationalized banking sector, with its system of directed credit, and simultaneous forced holdings of government and PSU loans, which have left bank portfolios in bad shape, is not well placed to provide small-scale financing of this kind. In particular, in the case of TARAhaat, difficulties in obtaining startup capital from banks appeared to be a major impediment to rapid expansion of the franchising scheme, even within a small geographic area.[57] This is where the overall macroeconomic problem of the fiscal deficit appears to trickle down all the way to the village, with a negative impact on development.

Our general assessment of the policy environment is therefore that, with one exception, the policy problems are mostly general ones, and not specific to IT. Problems in financial market institutions, labor laws, and regulation in general are best dealt with from an economy wide perspective, as we elaborate on in the conclusion. The exception is the case of rural telecoms and Internet access, where it seems that narrow targeting of limited subsidies (through waiving certain fees rather than explicit payments) for startup costs may be worthwhile in generating growth of communications, and of enterprises that use communications.

6. Conclusion

To conclude, we will briefly consider general microeconomic and macroeconomic policy issues, and implications for the IT sector. The central areas of India's policy reforms have been replacing quantitative trade restrictions with tariffs, lowering effective levels of protection, removing an area of discretionary controls on private sector investment, and creation of modern financial markets. Standard examples of where these reforms can be built upon, to further stimulate growth, include removal or relaxation of obsolete "small-scale sector" reservations and size restrictions, privatization of inefficient state-owned enterprises, rationalization of tax-subsidy policies and tax administration, and relaxation of severe labor market restrictions. This list can be characterized by its emphasis on improving the efficiency of the mechanisms with which the government directly affects the private sector. The entire Indian economy, not just the IT sector, can presumably benefit from such reforms, which will reduce distortions of private sector behavior.

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[57] Drishtee was able to avoid this problem to some extent, with smaller-scale kiosks that allowed poorer entrepreneurs to avail of targeted government loan schemes.

A second area where attention is required may be characterized as enabling reforms. These include reforms of contract law and judicial institutions; financial sector regulatory institutions; telecom sector regulatory institutions; infrastructure such as electric power, roads and ports; and systems of education and training in general. Again, the benefits of such reforms are potentially quite general, and not restricted to any one sector of the economy.

A third area of policy is macroeconomic management. While India's record here is quite good, it needs to make a transition in its policy institutions here as well, since removing detailed microeconomic controls requires changes in the regulatory modes of macroeconomic management. Perhaps the area that has received the most attention is policies toward international capital flows and their implications for exchange rate management. Desai (2000) has suggested that large projected increases in software exports could create a "Dutch disease" phenomenon,[58] in which a resulting exchange rate appreciation hurts other sectors, and revenues from exports are wastefully spent. Several factors mitigate this concern: the likelihood that export revenue growth will slow down; the potential linkages that exist between software, the IT sector as a whole, and the broader economy (unlike natural resource extraction enclaves); and a better understanding of exchange rate management than existed 25 years ago, when the phenomenon first was identified and labeled. Thus, while exchange rate policy is certainly important in general, the growth of the IT sector will not necessarily raise special concerns.

Given that there is plenty that remains to be done in terms of overall economic policy reform, are there areas where the IT sector deserves special attention? The answer we have given in this paper, with one exception, is "no". Special subsidies or export incentives are likely to be inefficient ways of stimulating the growth of the IT sector, or of positive spillovers for the rest of the economy. Similarly, special central government initiatives to increase the availability of IT training and related education are also likely to represent a mistargeting of scarce government resources. The same stricture applies, to some extent, to state government policies to encourage the IT sector.[59] The government may be better off removing general restrictions to doing business, as well as providing an enabling institutional infrastructure (appropriate laws and regulations), rather than attempting to target the IT sector through a form of industrial policy.

The exception lies in the telecom sector, which has particularly strong complementarities with the broader IT sector. Policies to achieve development goals would do better to emphasize removing barriers to innovations that will support lower-cost access to telecom networks of all kinds (wireless and fixed, voice and data). Very specific, targeted, startup subsidies to enable widespread, shared access to telecoms and Internet in rural areas are likely to have high social returns, since it appears that financially sustainable franchise models exist. These high returns include better governance, as well as knowledge that is an important input into 'empowerment', or 'development as freedom' (Sen, 1999). In this respect, we would argue that rural IT access is

[58] An excellent explanation of Dutch disease is by John McLaren, at www.columbia.edu/~jem18/teaching/pepm/dutchdis.pdf. McLaren clarifies the source of concerns that are associated with Dutch disease, including exacerbation of *prior* distortions, and of inequality.

[59] Bangalore in Karnataka is well known as a regional IT center in India, having developed initially without much explicit government support. The governments of Andhra Pradesh (Eischen, 2000) and Tamil Nadu (Bajpai & Radjou, 1999, and Bajpai & Dokeniya, 1999) have led in attempts to establish IT-based industries with conscious government policies. Other state governments, such as Punjab (see www.dqindia.com/mar1599/news.htm) are following suit, with mixed success.

an important complement to and enabler of local government reform in India (Rao and Singh, 2000).

Our goal in this paper has been to assess the possible role of India's IT industry as a driver of higher economic growth in India, without exacerbation of inequalities or creation of instability. Our conclusion is cautiously positive. While projections for software exports may be over optimistic, complementarities or spillovers in the domestic market, including increased government and business use of IT, are likely to be strong. For this rosy scenario to play out, however, continued broad economic reforms will be important, as well as reforms in the telecom sector that promote competition and innovation in providing last-mile access.

References

Aggarwal, Balaka B. (2001), Faculty scarcity at IITs threatens knowledge capital, March 19, http://www.ciol.com/content/news/trends/10103902.asp.

Arora, Ashish and V. S. Arunachalam, Jai Asundi and Ronald Fernandes (2000), The globalization of software: the case of the Indian software industry. A report submitted to the Sloan Foundation. Carnegie Mellon University, Pittsburgh PA. http://www.heinz.cmu.edu/project/india/publications.html.

Arora, Ashish, V. S. Arunachalam, Jai Asundi and Ronald Fernandes (2001a), The Indian Software Service Industry, *Research Policy*, 30, 1267-1287.

Arora, Ashish and Suma Athreye (2002), The Software Industry and India's Economic Development, *Information Economics and Policy*, 14, 253-273.

Arora, Ashish, Alfonso Gambardella and Salvatore Torrisi (2001b), In the footsteps of the Silicon Valley? Indian and Irish Software in the International Division of Labour, paper presented at the conference, 'Silicon Valley and its Imitators', Stanford Institute for Economic Policy Research, July 2000.

Bajpai, Nirupam and Navi Radjou (1999), Raising the Global Competitiveness of Tamil Nadu's Information Technology Industry, Development Discussion Paper No. 728, October, Harvard Institute for International Development.

Bajpai, Nirupam and Anupama Dokeniya (1999), Information Technology-Led Growth Policies: A Case Study of Tamil Nadu, Development Discussion Paper No. 729, October, Harvard Institute for International Development.

Banerjee, Abhijit V. and Esther Duflo (2000), Reputation Effects and the Limits of Contracting: A Study of the Indian Software Industry, *Quarterly Journal of Economics*, 115,3, 989-1017.

Basu, Kaushik (1997), *Analytical Development Economics*, Cambridge, MA: MIT Press.

Basu, S. and Weil, D.N. (1998), Appropriate Technology and Growth, *Quarterly Journal of Economics*, 113, 4, 1025-1054.

Bhatnagar, Subhash and Robert Schware (2000), *Information and Communication Technology in Development: Cases from India*, New Delhi: Sage Publications.

Bjorhus, Jennifer (2002), India's Infosys Struggles through Transformation, *San Jose Mercury News*, February 11, 1E.

Bresnahan, Timothy and Manuel Trajtenberg (1995), General Purpose Technologies: "Engines of Growth", *Journal of Econometrics*, 65, 83-108.

Business Week (2001), India 3.0: Its software outfits take on the world, February 26, 44-46.

Chuang, Y.C. (1998), Learning by Doing, the Technology Gap, and Growth, *International Economic Review*, 39, 3, 697-721.

Ciccone, Antonio and Kiminori Matsuyama (1996), Start-up Costs and Pecuniary Externalities as Barriers to Economic Development, *Journal of Development Economics*, 49, 33-59.

Das, Shyamanuja (2001), The Indian Challenge: Will They…Or Won't They?, March 7, http://voicendata.com/content/top_stories/101030703.asp.

Dataquest (2001), SW INDUSTRY: Working around the Slowdown, February 14, http://dqweek.ciol.com/content/search/showarticle.asp?artid=21244.

David, Paul A., Understanding Digital Technology's Evolution and the Path of Measured Productivity Growth: Present and Future in the Mirror of the Past, in Erik Brynjolfsson and Brian Kahin, eds., *Understanding the Digital Economy*, Cambridge, MA: MIT Press, 2000, 49-98.

DQ Week (2001), Medical Transcription: Not in the Pink of Health, February 2, http://www.ciol.com/content/search/showarticle.asp?artid=21128.

Desai, Ashok V (2000), The Peril And The Promise: Broader implications of the Indian presence in information technologies, Working Paper, August, CREDPR, Stanford University.

Dey Atanu (2000), New Telecom Policy 1999: A Critical Evaluation, paper presented at Conference on Telecommunications Reform in India, Asia/Pacific Research Center, Stanford University, November 9 & 10.

Dossani, Rafiq and Robert T. Crow (2001), Restructuring the Electric Power Sector in India: Alternative Institutional Structures and Mechanisms, Working paper, Asia/Pacific Research Center, Stanford University.

Dossani, Rafiq and Martin Kenney (2001), Creating an Environment: Developing Venture Capital in India, Working paper, Asia/Pacific Research Center, Stanford University.

Dossani, Rafiq and S. Manikutty (2000), Reforms in the Telecommunications Sector in India: An Institutional View, paper presented at Conference on Telecommunications Reform in India, Asia/Pacific Research Center, Stanford University, November 9 & 10.

Dossani, Rafiq and Lawrence Saez (2000), Venture Capital in India, *The International Journal of Finance*, 12, 4, 1932-1946.

Drèze, Jean and Haris Gazdar (1997), Uttar Pradesh: The Burden of Inertia, in Amartya Sen and Jean Drèze, *Indian Development: Selected Regional Perspectives*, Delhi: Oxford University Press.

Dudley, Leonard (1999), Communications and Economic Growth, *European Economic Review*, 43, 595-619.

Economist, The (2001a), Another kind of net work: Mobile phones in India, March 3, 59.

Economist, The (2001b), Outsourcing to India: Back office to the world, May 5, 59.

Eggleston, Karen, Robert Jensen and Richard Zeckhauser (2002), Information and Communication Technologies, Markets and Economic Development, working paper, Economics Department, Tufts University and John F. Kennedy School of Government, Harvard University.

Eischen, Kyle (2000), National Legacies, Software Technology Clusters and Institutional Innovation: The Dichotomy of Regional Development in Andhra Pradesh, India, University of California, Department of Sociology.

Gordon, Robert J., Does the 'New Economy' Measure Up to the Great Inventions of the Past?, *Journal of Economic Perspectives*, Fall 2000, 14(4), 49-74.

Grossman, Gene and Elhanan Helpman (1991), *Innovation and Growth in the Global Economy*, Cambridge, MA: MIT Press.

Hanna, Nagy (1994), Exploiting Information Technology for Development: A Case Study of India, World Bank Discussion Paper 246.

Heeks, Richard (1998), The Uneven Profile of India's Software Exports, IDPM Working Paper No. 3, October, University of Manchester.

Heeks, Richard (1996), *India's Software Industry: State Policy, Liberalisation and Industrial Development.* Sage Publications, New Delhi, Thousand Oaks and London.

Helpman, Elhanan (1998), *General Purpose Technologies and Economic Growth*, ed., Cambridge: MIT Press.

Helpman, Elhanan and Manuel Trajtenberg (1998a), A Time to Sow and a Time to Reap: Growth Based on General Purpose Technologies, Ch. 3 in Helpman (1998).

Helpman, Elhanan and Manuel Trajtenberg (1998a), Diffusion of General Purpose Technologies, Ch. 4 in Helpman (1998).

India Today (2000), Is e-Governance for Real?, December 11, pp. 70-75.

Jhunjhunwala, Ashok (2000), Unleashing Telecom and Internet in India, Paper presented at the Conference on Telecommunications Reform in India, Asia/Pacific Research Center, Stanford University, November 9 & 10.

Jorgenson, Dale W., Information Technology and the U.S. Economy, *American Economic Review*, March 2001, 91(1), 1-32.

Kapur, Devesh (2002), The Causes and Consequences of India's IT Boom, *India Review*, 1, 1, 91-110.

Kapur, Devesh and Ravi Ramamurti (2001), India's Emerging Competitive Advantage in Services, *Academy of Management Executive*, 15, 2, 20-31.

Kaushik, P.D. and Nirvikar Singh (2002), Information Technology and Broad-Based Development: Preliminary Lessons from North India, UC Santa Cruz Working Paper, in progress.

Khoo, Ernest (2002) The Simputer: A Handheld for the Masses?, CNET News.com, January 11, http://news.com.com/2100-1040-808321.html.

Kremer, Michael (1993), The O-Ring Theory of Economic Development, *Quarterly Journal of Economics*, 108, 3, 551-575.

Kumar, Nagesh (2000), New Technology Based Small Service Enterprises and Employment: The Case of Software and Related Services Industry in India, International Centre for Development Research and Cooperation, New Delhi.

Lipsey, Richard G., Cliff Becker, and Kenneth Carlaw (1998), What Requires Explanation?, Ch. 2 in Helpman (1998).

Matsuyama, Kiminori (1995) Complementarities and Cumulative Processes in Monopolistic Competition, *Journal of Economic Literature*, 33, 2, 701-710.

Milgrom, Paul, Yingyi Qian, and John Roberts (1991), Complementarities, Momentum, and the Evolution of Modern Manufacturing, *American Economic Review*, May, 81, 2, 84-88.

Miller, Robert R. (2001), Leapfrogging? India's Information Technology Industry and the Internet, IFC Discussion Paper No. 42, May, The World Bank, Washington, DC.

National Association of Software and Service Companies (2002a): Domestic IT Market. New Delhi. http://www.nasscom.org/it_industry/domestic_it_market.asp.

National Association of Software and Service Companies (2002b): Domestic software. New Delhi. http://www.nasscom.org/it_industry/domestic_sw_services.asp.

Pohjola, Matti (1998), Information Technology and Economic Development: An Introduction to the Research Issues, WIDER Working Paper No. 153, November, United Nations University.

Prahalad, C. K. and Stuart L. Hart (2002), The Fortune at the Bottom of the Pyramid, http://www.strategy-business.com/media/pdf/02106.pdf.

PROBE committee (1999), Public Report on Basic Education in India, Centre for Development Economics, New Delhi: Oxford University Press.

Rao, M. Govinda, and Nirvikar Singh (2000), How to Think about Local Government Reform in India: Incentives and Institutions, Paper presented at International Conference on Second Generation Reforms in India, Madras School of Economics, Chennai.

Ray, Debraj (1998), *Development Economics*, Princeton: Princeton University Press.

Rivera-Batiz, Luis A. and Paul M. Romer (1991), Economic Integration and Endogenous Growth, *Quarterly Journal Of Economics*, 106, 2:531-555.

Rivera-Batiz, Luis A. and Paul M. Romer (1991), International Trade With Endogenous Technological Change, *European Economic Review*, 35, 4:971-1004.

Saxenian, AnnaLee (2000), The Bangalore Boom: From Brain Drain to Brain Circulation?, forthcoming in Kenneth Keniston and Deepak Kumar, eds., *Bridging the Digital Divide: Lessons from India*, Bangalore: National Institute of Advanced Study.

Saxenian, AnnaLee (2001), Bangalore: The Silicon Valley of Asia?, Working paper No. 91, Center for Research on Economic Development and Policy Reform, Stanford University, February.

Sen, Amartya K. (1999), *Development as Freedom*, Oxford, Oxford University Press.

SGKI (2000), Subject Group on Knowledge-based Industries, Prime Minister's Council on Trade and Industry. *Recommendations of the Task Force on Knowledge-based Industries.* Prime Minister's Office, New Delhi. http://www.nic.in/pmcouncils/reports/knowl/

Singh, Nirvikar (2002), Information Technology as an Engine of Broad-Based Growth in India, in *The Future of India and Indian Business*, ed. P. Banerjee and F.-J. Richter, London: Macmillan.

Singh, Nirvikar and T.N. Srinivasan (2002), Indian Federalism, Economic Reform and Globalization, paper for comparative federalism project, CREDPR, Stanford.

Tschang, Ted (2001), The Basic Characteristics of Skills and Organizational Capabilities in the Indian Software Industry, Working Paper No.13, ADSB Institute, Tokyo.

Telecom Regulatory Authority of India (2000), Consultation Paper on Issues Relating to Universal Service Obligations. TRAI, New Delhi, July 3.

Verma, M. S. (2000), TRAI's Objectives and Policy Focus in a Changing Environment, Paper presented at the Conference on Telecommunications Reform in India, Asia/Pacific Research Center, Stanford University, November 9 & 10.

Woodall, Pam (2000), The New Economy, *The Economist*, September 23, Survey p. 6.