
INFORMATION TECHNOLOGY IN INDIA

The Quest for Self-Reliance

Jason Dedrick and Kenneth L. Kraemer

Information technology (IT) is one of the fastest spreading technologies in the world in terms of use and production. Its use is ubiquitous in the industrialized countries, to the extent that in the United States investment in IT accounts for about 50% of total new capital investment by corporations. The production of IT products and services is a major industry in the U.S., Japan, and Europe; several newly industrializing countries, such as Korea, Taiwan, Singapore, and Brazil, have become significant producers and users of IT; and many developing countries are beginning the process of computerization.

This evolution of computers and other forms of IT has been marked by heavy government involvement in virtually all countries. Institutions such as the U.S. Department of Defense and Japan's Ministry of International Trade and Industry (MITI) have influenced and spurred the development of information technologies in various ways, including acting as leading users of IT, supporting research and development, and regulating and providing incentives to the private sector. While U.S. government policies have generally been implemented on an ad hoc basis, the Japanese government has pursued a more coordinated strategy. Believing that competence in IT will be vital to future economic development and observing the importance of government efforts in the developed countries, a number of

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developing and newly industrializing countries (NICs) have pursued government policies to promote domestic production and/or use of IT.¹

Of all the NICs and developing countries, India stands out for the degree to which its government has intervened in the IT sector and for the complexity and nuance of that intervention. Through the 1970s, the Indian government acted as a regulator of the private sector and as a producer of computing products and services; in the 1980s, it reduced its regulatory role somewhat and began to act more as a promoter of production by the private sector. The Indian case illustrates the successes that can be achieved through government intervention but also points out the limitations of intervention as well as the problems associated with particular policy approaches.

India has been successful in building an indigenous domestic computer industry capable of producing hardware for the local market and software for export. Growth in domestic hardware production has averaged over 70% per year, and growth in software exports has averaged over 45% per year since the early 1980s. Hardware prices have dropped dramatically since the mid-1980s, and Indian companies have marketed with leading products, such as 386-based personal computers (PCs), soon after they were introduced in the industrialized countries. However, these successes have been achieved at considerable cost to other sectors of the economy, to subsectors of the IT industry, and to the long-term viability of the domestic IT industry. The costs of such policies include the following:

1. Other industries cannot obtain low-cost computing, since prices remain about two-and-a-half times higher than world prices. This limits the application of IT to improve the efficiency of those industries.
2. Policies to protect domestic hardware producers have hurt the software industry by limiting its access to needed hardware and to software development tools. Higher prices due to import protection have also limited the diffusion of computer hardware, limiting local demand for software.
3. Policies to prevent monopolization of the market have created a fragmented computer industry with over 200 producers of PCs, none of

1. A variety of policy approaches can be observed among the newly industrializing countries: Korea and Brazil have adopted market reserve policies (since dropped in Korea) in the microcomputer area to protect domestic producers from foreign competition, while Singapore and Hong Kong have maintained open markets for imports. The East Asian NICs have promoted exports, while Brazil has targeted the domestic market. Korea and Taiwan have emphasized the development of IT production, while Singapore made IT use a priority in its National Information Technology Plan. A detailed account of the Japanese government's policies to promote a domestic computer industry is by Marie Anchordoguy, *Computers Inc.: Japan's Challenge to IBM* (Cambridge, Mass.: Harvard University Press, 1990).

which achieve economies of scale necessary to match international prices.

4. Hardware production consists mainly of assembly of imported components with little or no value added in India.

India's past and present policies have been largely responsible for these successes and failures. Unraveling those policies and understanding how they came to be is critical to developing lessons for future policy in India and in other countries. Several recent analyses have discussed various aspects of India's experience with information technology and its government's policies toward IT.² This article builds on these analyses by employing an explicit framework that focuses on the relationships among policies, environmental factors, and outcomes in terms of IT production and use. It also looks closely at the interaction of different policies, for example, how hardware policies have had a significant impact on the software industry or how policies to promote production have affected use.

Analytical Framework

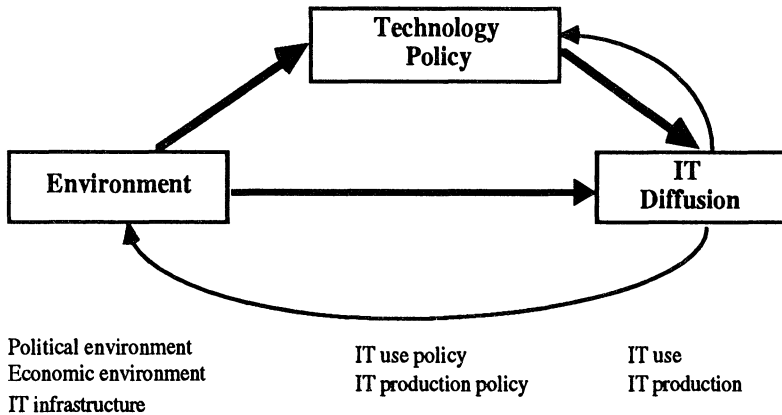
The role of government policy with respect to the diffusion of IT in India can only be understood in the context of broader environmental factors. The general framework for analysis in Figure 1, therefore, posits that environmental factors constitute independent variables that affect technology diffusion in two ways: directly, and indirectly through the mediation of policy (shown by bold, straight lines). This is a static view, however, because we know that over time the consequences of policy will affect the environment (shown by thin curved lines). In fact, this is precisely the assumption of arguments in favor of industrial and technology policy: that the outcomes of the policy will bring environmental changes in the forms of improved economic and social welfare. The analysis of the Indian case is organized according to the contents of Figure 1: environment, technology policy, and IT diffusion.

Environment

Political and Economic Environment

Modern politics in India, up to now, were dominated by the desire to gain independence from the British and then to remain independent from the

2. Hans-Peter Brunner, "Building Technological Capacity: A Case Study of the Computer Industry in India, 1975-87," *World Development*, 19:12 (1991), pp. 1,737-1,751; Robert Schware, "Software Industry Entry Strategies for Developing Countries: A 'Walking on Two Legs' Proposition," *ibid.*, 20:2 (1992), pp. 143-64; Peter B. Evans, "Indian Informatics in the 1980s: The Changing Character of State Involvement," *ibid.*, 20:1 (1992), pp. 1-18.

FIGURE 1 *Model for Research*

major superpowers during the Cold War. Since independence in 1947, India has followed a generally socialist economic policy within a democratic political framework, but in 1991 the new government of Prime Minister P. V. Narasimha Rao instituted a number of market-oriented reforms that are beginning to move India away from its socialist orientation.

India's post-independence economic policies have been aimed at developing a domestic industrial base in order to achieve rapid growth and economic independence to go along with political independence. To do this, the government directed investment into heavy capital goods industries such as coal, steel, and fertilizers, rather than starting with consumer goods. But despite the emphasis on central planning, India did not try to establish state control over the entire economy. A mixed economy was favored with the public sector dominating basic and heavy industries and the private sector focusing on light industry and services.

Beginning in the 1950s, the Indian government implemented a strategy of import-substituting industrialization (ISI) in which local industry was to produce manufactured goods to replace imports. This approach followed the pattern of many developing countries at the time and also fit in well with the notion of self-reliance, which was interpreted as self-sustained growth without dependence on foreign aid. However, like many countries pursuing ISI, India found itself unable to develop many key industries due to a lack of technology and capital equipment. The government reluctantly turned to multinational corporations (MNCs), and starting in the late 1950s, they were invited into the country with few re-

strictions. In the 1960s, MNCs gained dominant market shares in key industries such as chemicals, electric machinery, and computers.

Much of the MNC investment involved collaboration with the large Indian business houses, twenty of which controlled a quarter of all of India's corporate assets in 1969. Despite government efforts to curb their economic power (such as nationalizing the business house-controlled banks), these great firms continued to grow, with Tata and Birla doubling their share of India's total private assets from 1963 to 1973.³ The predominance of the large houses has had two important effects on the IT industry. One is that Tata has become a leading force in the industry through its own software division and through a joint venture with Burroughs (now Unisys), which makes personal computers. Another, more indirect, effect has come from the government's efforts to limit the economic power of the major groups through the Monopoly and Restrictive Trade Policy (MRTP) Act of 1969. This act required any company that had assets over 20 million rupees, was financially connected with a company of that size, or sold more than 60% of any product or service produced on the Indian market to obtain government permission to expand production or establish new capacity. This was applied to the IT industry to limit the output of computer producers, and it helped create a fragmented industrial structure composed of many small companies.

Along with attempting to limit the power of the business houses, India also began a concerted effort to reduce the influence of the MNCs. In 1973 the Foreign Exchange Regulation Act (FERA) was modified to require foreign investors to reduce their equity shares to 40% in any venture, with exemptions for "high priority industries"—usually export-oriented operations or those in high-technology areas. Most foreign firms agreed to comply with the requirements, but two high-profile corporations, International Business Machines (IBM) and Coca Cola, eventually chose to quit India rather than go along with the new regulations. Government control over the private sector increased over time, going far beyond limits on foreign investment. Permission was required to import capital goods and to license technology, and the government kept tight control over access to foreign exchange. A system of high tariffs and license requirements limited imports and created a protected market for domestic producers.

The results of such regulation have been predictable, at least from the neoclassical economists' point of view. The private sector has realized that its prosperity depends largely on gaining access to import licenses, foreign exchange, operating permits, and other government favors rather than on

3. V. N. Balasubramanyam, *The Economy of India* (London: Weidenfeld and Nicolson, 1984).

its ability to improve the quality or reduce the price of its products. Rent seeking (attempting to gain favorable treatment from policy makers) has taken precedence over innovation, and those businesses with the best political connections have profited while the economy as a whole had stagnated. Manufacturers rarely achieve economies of scale in production and have had little incentive to invest in technologies to reduce cost or improve quality. Consumers are forced to pay high prices for inferior items. Labor unions have fought automation that might threaten jobs, and have supported the status quo regarding imports as unionized workers prosper in protected industries. Finally, state-owned enterprises have remained generally inefficient and unprofitable, dominating key industries and hampering the growth of the private sector.

By the 1980s, it was apparent to the government that 35 years of inward-looking policies had not achieved rapid economic growth, self-reliance, or a major improvement in the standard of living for the Indian people. A reform process began to take form when Rajiv Gandhi took office as prime minister in 1984. Gandhi recognized that government regulation had become a major obstacle to growth and that the public sector was a drain on the economy. He initiated a program of economic liberalization aimed at making Indian industry competitive and increasing exports. His reform program included steps to simplify the tax system and shift import controls from licensing requirements to tariffs. But the most significant decision was to rely on the private sector as the primary source of new capital investment, while trying to improve the performance of the state-owned sector. But the reforms initiated were tepid at best. There was no effort to reduce subsidies for food and fuel, make state-owned enterprises more productive, or open up the economy to real competition from abroad. Tariff rates remained prohibitively high, and many licensing requirements were not eliminated. The government continued to prop up insolvent companies rather than allow them to shut down, and the FERA remained in effect, acting as a strong barrier to foreign investment.

The results of these reforms were mixed, as shown in Tables 1 and 2. For most of the 1980s, the economy did reasonably well compared to many developing countries (e.g., Malaysia and Indonesia). However, India entered a recession in 1989 and encountered serious balance-of-payments problems. In 1991 the government of Prime Minister Rao implemented a broad reform program, partly as a condition for receiving a two-billion dollar standby loan from the International Monetary Fund. Foreign investment restrictions were eased, with limits on foreign equity raised from 40% to 51%, and most licensing procedures abolished. The rupee was devalued by 30% and the government is considering moving to full convertibility. So far, the government has not changed national labor

TABLE 1 *Growth in GNP Per Capita for Selected Asia-Pacific Countries*

<i>Country</i>	<i>1965–1980</i>	<i>1980–1988</i>
South Korea	7.3	7.7
Singapore	8.3	5.8
Hong Kong	6.2	5.7
Malaysia	4.7	1.3
Indonesia	5.2	1.7
India	1.5%	3.3%

SOURCE: United Nations Development Program, *Human Development Report, 1991*.

TABLE 2 *Percentage of Workers in Agriculture, Industry, and Services*

<i>Year</i>	<i>Agriculture</i>	<i>Industry</i>	<i>Services</i>
1965	73.0	12.0	15.0
1985–87	62.6	10.8	26.6

SOURCE: United Nations Development Program, *Human Development Report, 1991*.

laws, allowed state-owned enterprises to go out of business, or seriously reduced the size of the government bureaucracy. Such changes are considered necessary if foreign and domestic investment are to increase substantially.⁴

A broad indicator, composition of the workforce over time, is instructive of the evolution of the Indian economy. Table 2 shows that there has been a slight decrease in industry as a percentage of employment and a near doubling of service employment between 1965 and 1985. This pattern is hardly consistent with a country promoting industrialization, but it is consistent with the notion expressed by some observers that India is in fact a trade-oriented society and that its high degree of manufacturing is largely an illusion. This view is that the government really has a short-term trading focus rather than a long-term focus on building a manufacturing base. The computer industry provides evidence of this; its practice of assembling imported components for final sale is closer to trading than

4. *Economist*, "Freeing India's Economy," May 23, 1992, pp. 22–23.

manufacturing. Also, the practice of “bodyshopping” or sending programmers abroad on a contract basis shows a trading orientation.

IT Infrastructure

The assimilation of any new technology requires the presence of an infrastructure with which to acquire, learn, and successfully apply the technology. This applies to both the use of the technology and the production of products and services embodying the technology. For information technology, the necessary infrastructure includes human resources, telecommunications networks, research and development capabilities, and capital for investment.

Human resources. A key to success in any high-technology sector such as IT is human resources. A country must not only provide necessary training to sufficient numbers of people but it must create an environment in which those people can utilize their skills to make a decent living. Otherwise, they are likely to leave for other countries where the opportunities are greater. The Indian government’s policies to promote the development of a domestic computer industry have been justified, in part, by the argument that India has a large pool of human resources that can be mobilized to achieve that goal. Table 3 provides a comparison of India’s human resources with other Asia-Pacific countries.

What immediately stands out in Table 3 is the number of scientists and engineers in India and even their share of the population, which compares favorably with the East Asian NICs. India turns out an estimated 160,000 graduates with technical and engineering degrees per year.⁵ It is misleading to look at average numbers when considering India’s population. India can almost be seen as two societies, with the poor and traditional sectors accounting for about 650 million, while the upper and middle classes consist of about 200 million people. It is this middle class that is the potential market for IT products, as well as the workforce for the IT industry. According to various sources, India has the third largest pool of engineering and scientific manpower in the world. The caliber of many of those people is world class, especially graduates of the Indian Institutes of Technology (IITs), many of whom go to the U.S. and Europe for advanced study and then, careers.

Despite the large overall number of technically trained people, there appears to be an impending shortage of IT professionals. The government’s Eighth Plan projects a shortage of 40,000 computer professionals for every year of the plan period, due partly to the fact that the educational system

5. Silicon Valley Indian Professionals Association, notes from presentation, 1991.

TABLE 3 *Human Resource Indicators for Selected Asia-Pacific Countries*

	<i>Adult Literacy^a</i>	<i>Secondary Enrollment^a</i>	<i>Education Exp. as % of GNP^a</i>	<i>Number of Scientists and Engineers^b</i>	<i>Scientists and Engineers Per 10,000 Population^b</i>
Australia	99%	96%	5.1	38,568	23.4
New Zealand	99	84	4.8	4,091	13.6
United States	96	99	5.3	949,200	39.5
Japan	99	97	5.0	416,850	33.8
Korea	99	95	4.9	63,115	14.9
Taiwan	90 ^c	87 ^c	n.a.	25,612	18.0
Singapore	86	71	5.2	5,876	23.0
Hong Kong	88	69	n.a.	n.a.	n.a.
Malaysia	74	59	7.9	5,537	3.0
India	43	38	3.4	2,000,000 ^d	25 ^d

^a United Nations Development Program, *Human Development Report, 1990*.

^b Pacific Economic Cooperation Conference, Science and Technology Task Force, *Pacific Science and Technology Profile, 1991*.

^c Republic of China, *Statistical Yearbook of the Republic of China, 1984*.

^d Silicon Valley Indian Professionals Association (note: definition of scientists and engineers may be different from other countries).

has not adjusted to train more people with the necessary skills. Another problem is the inconsistent quality of technical institutions below the IIT level. Even more serious is the brain drain due to migration out of the country. A study by IIT/Madras noted that migration has increased from 20% of IIT graduates in 1968–72 to 35% in 1983–87. For computer science graduates, the figure in 1986 and 1987 was 58.5%. Some of India's best people are emigrating to countries where they can earn better salaries and find professional challenges unavailable in the Indian industry.⁶

Evidence of the caliber of these expatriates is the success of non-resident Indians (NRIs) in the United States, where they are an important part of the Silicon Valley (California) scene. Vinod Khosla, the son of an Indian army officer, was one of the founders of the high flying computer maker, Sun Microsystems. Sun's VLSI design engineer is another NRI, Anant Agarwal. The success of the NRIs is clear evidence of the high caliber of IT professionals turned out by Indian universities. The government has

6. A. Malhotra, "We Need More Trained People," *Dataquest*, December 1990, p. 133.

TABLE 4 *Number of Telephones Per 1,000 Population*

<i>Country</i>	<i>Number</i>
Australia	436
United States	520
Japan	403
Taiwan	262
Singapore	340
Malaysia	68
Philippines	7
India	5

SOURCE: Siemens, *International Telephone Statistics*, 1989.

tried to lure the NRIs back to India through various incentives, but those who have returned have found an environment where their knowledge and experience is often not valued, but seen as a threat. A major change in the economic and working environment will be necessary if India is going to keep its best IT professionals and encourage NRIs to return.

Telecommunications. A good telecommunications network is another vital element of the IT infrastructure. Without adequate telecommunications, computer centers remain isolated units, and organizations that wish to connect units in different locations must invest in expensive dedicated communication links. India has very poor telephone service (see Table 4), but in 1985 the government initiated a new policy that permitted Indian companies producing telecommunications equipment to collaborate with foreign companies in order to gain access to technology. The Seventh Five-Year Plan (1985–1990) allocated \$4.5 billion in investment funds for telecommunications, and India has identified the sector as one of its top five development priorities.

Research and development/technology transfer. India's industrialization has depended heavily on imported technology, much of which was acquired through technology licensing and technical collaboration agreements. Research and development by Indian companies has been largely oriented toward adapting imported technologies to domestic requirements, and in some cases has helped Indian companies to develop their own technology. Interestingly, joint ventures spend more on R&D than Indian-owned enterprises, and among Indian enterprises, those who license tech-

TABLE 5 *R&D Expenditures for Selected Pacific Rim Countries*

	<i>R&D Expenditure as % of GNP (1988)</i>	<i>Business Exp. on R&D as % of Total R&D</i>
Australia	1.32	36.5
New Zealand	0.97	22.3
United States	2.66	70.3
Japan	2.85	66.0
South Korea	1.63	29.6
Taiwan	0.85	47.2
Singapore	0.89	43.0
Philippines	0.12 ('84)	19.4
Indonesia	0.24	n.a.
India	0.91	13.0

SOURCE: *World Competitiveness Report, 1990*; except Philippines, Pacific Economic Cooperation Conference, Science and Technology Task Force, *Pacific Science and Technology Profile 1991*.

nology do more R&D than those who don't.⁷ This suggests that technology transfer stimulates, rather than replaces domestic R&D, a finding that contradicts prevailing development theories. India's R&D expenditures are well ahead of other developing countries in the Asia-Pacific region, and are even comparable to New Zealand and Singapore (see Table 5). However, business R&D accounts for only 13% of the total, meaning that R&D is largely conducted by the public sector and universities where it may not be relevant to economic applications.

In an effort to create ties between research and industry, the government has established "science cities" around research institutions to serve as centers for high-tech industrial development. One goal of these centers is to attract NRI scientists and engineers living abroad to return to India as entrepreneurs, a strategy that has worked well for Taiwan in the Hsinchu Science-based Industrial Park. The government has also encouraged R&D by the multinational corporations by granting exemptions to the FERA for companies employing "sophisticated technology" in their Indian subsidiaries.

7. Dennis J. Encarnation, *Dislodging Multinationals: India's Strategy in Comparative Perspective* (Ithaca, N.Y.: Cornell University Press, 1989).

Capital. Savings equalled 22% of GNP in 1987, a rate comparable to most Western countries but well below the levels of the East Asian NICs. However, the budget deficit that year was running at 8.1% of GNP, reducing the savings available for private investment. Capital for investment in IT is scarce. Banks tend to be conservative and lack experience with high-tech industries, while the venture capital industry is not well developed. Some resources are available for investment in IT through the business houses, which have access to profits earned in other activities. It is not clear that lack of capital has been a major constraint on IT diffusion but it may be as the industry expands.

Thus, the broad environment for IT diffusion in India is generally poor, although the situation seems to be changing under the present government. The highly protected domestic market benefits local producers but at a high cost to users. Strict controls on foreign investment have limited India's access to critical technologies and capital. Although the government has been stable and democratic since independence, religious and ethnic clashes make India appear to be a relatively risky investment climate. The future of the economy may depend on the ability of the government to make reforms while maintaining political stability. The quality of India's IT infrastructure is spotty at best. India's strong suit is its human resource base, but this resource is not being deployed as effectively as it could due to the lack of dynamism in the private sector and problems in adjusting the educational system to meet the needs of industry. India's telecommunications network is desperately inadequate and is hampering the development of IT use and production. R&D spending is reasonably high for a developing country but is focused in the public sector. Government supported R&D has weak links to commercial demand, although some efforts are being made to improve the situation. Finally, capital is in short supply for a high risk industry such as IT. The development of IT production and use has been determined partly by general economic conditions and the nature of the infrastructure. However, the Indian government has directly intervened in the IT sector to a great extent as well, shaping the levels and patterns of both production and use.

Technology Policy

The history of IT policy in India can be divided into two distinct periods. From the mid-1960s through the early 1980s, policies aimed at achieving technological self-sufficiency through state production, regulation of private production, and dislodging IBM from its dominant market position. The second period, from 1984 to the early 1990s, saw a shift in focus to moderate liberalization of the industry and promotion of domestic IT pro-

duction. Another era may now be in the making as the government moves toward more extensive liberalization of the economy.

*1960s and 1970s: Indigenization
and Self-Sufficiency*⁸

India was motivated to try to develop self-sufficiency in computers and electronics largely by national security concerns related to border conflicts with China and Pakistan. The government created an Electronics Committee to devise a strategy for achieving self-sufficiency in electronics within ten years by “leapfrogging” ahead to absorb the most advanced products and technologies available. The goal was to achieve eventually the indigenization of technology, whereby India would move away from dependence on foreign technology and produce its own. This approach not only responded to the perceived security risks, but also fit the ideology of self-sufficiency that drove much of India’s post-independence political and economic agenda.

The main vehicle chosen to gain access to advanced computer technologies was negotiation with multinationals, primarily IBM, which dominated the computer market in India (from 1960–72, IBM accounted for over 70% of all computers installed in India). From 1966 to 1968, the Indian government tried to get IBM to share equity with local capital in its Indian operations, but IBM said it would leave the country before agreeing to equity sharing and the government let the matter drop. In an attempt to satisfy the government’s interest in developing domestic production, both IBM and British-owned ICL (International Computers, Ltd.) began to refurbish used computers in Indian plants and sell or lease them to Indian customers. IBM felt that India should evolve technologically from one level of sophistication to the next. However, a 1966 report by the Electronics Committee stated that such step-by-step technological evolution should be avoided and that India should leap ahead to the latest technologies. But at this point, the government was unable to impose its will on IBM whose strong position with users and export earnings from other products gave it bargaining leverage. The government’s early attempts to regulate the IT sector actually worsened the degree of technological backwardness as Indian users installed the domestically refurbished machines rather than importing newer models.

The government’s inability to regulate the MNCs effectively was partly due to institutional weaknesses in the agencies assigned the task. In 1966

8. Background on policies before 1980 is primarily from Joseph M. Grieco, *Between Dependency and Autonomy: India’s Experience with the International Computer Industry* (Berkeley: University of California Press, 1984).

responsibility for implementing the Electronics Committee report strategies had been given to the Department of Defense Supplies, with monitoring by a new agency, the Electronics Committee of India, which however, lacked a technical support staff and had no authority to compel action by other agencies. By 1971 the Department of Defense Supplies had a backlog of over 150 license requests for IT projects. After much criticism of the department by other agencies and the private sector, the government announced the formation of a Department of Electronics (DOE) and a new Electronics Commission. The commission was responsible for policy formulation and oversight and the department for day-to-day implementation of policies. The commission was given authority to direct other government units and to regulate private and public electronics enterprises, and it developed a professional staff capable of providing the necessary technical support to regulate the sector effectively. In 1975 the DOE was given power over the licensing of computer imports. Now the new Electronics Committee and DOE had the authority and capability to establish control over the development of IT in India, and they did exactly that.

One of the first steps taken was the establishment of the Santa Cruz Electronics Export Processing Zone (SEEPZ) near Bombay. Foreign and Indian investors were offered incentives to establish an export base in India, including tax breaks, cheap land, duty-free import of inputs, and a streamlined permit process. In return, the government required that all or most of the production be exported and that Indian components be used as much as possible. A second step was the creation of the state-owned ECIL (Electronics Corporation of India, Ltd.) as a national champion in mini-computer production. ECIL got almost all of the government's computer development funding and the DOE made it very difficult for private competitors to get operating licenses. The government's plan was to allow imports of mainframes and large minis, give the small mini market to ECIL, and allow private firms to compete in the micro sector. Thanks to this support, ECIL's market share ranged from 40% to 53% of the computer installations in India between 1973 and 1977. However, by the end of the decade, ECIL had failed to make a computer that was technologically sophisticated, price competitive, or delivered on time. The third and most important action taken by the Electronics Department and Commission was to challenge once again the position of the multinationals. Using FERA regulations, the government began to pressure IBM and ICL to dilute their equity to 40% in their Indian operations. ICL agreed to combine its two Indian operations and reduce its equity to 40%, but IBM refused.

Negotiations with IBM went on through 1976 and 1977, but before they took place, two important developments occurred. In 1975 the U.S. computer maker, Burroughs, entered into a joint venture with Tata Consultancy Services to export software and printers from SEEPZ. This meant the government had two MNCs (ICL and Burroughs) in the country on its own terms, which probably encouraged it to take a hard line toward IBM. Also in 1975, the Indian cabinet approved a proposal to set up the state-owned Computer Maintenance Corporation (CMC) with a legal monopoly on the maintenance of all foreign computer systems in the country. This reduced the advantage IBM had with users as a result of its superior service capabilities, as users would now have to depend on CMC no matter whose system they purchased. With its bargaining position substantially enhanced, the government continued to demand that IBM dilute its equity to 40% for all Indian operations. IBM responded with a proposal to share equity in its non-computer operations, meet export goals, and fund an Indian science center and an electronics testing facility. The government refused. After two years of negotiations, IBM decided it could not back down on the equity issue and in 1978 it quit India altogether.

IBM's exit was a seminal event, and it illustrated the extent of the government's ability to exert its power over multinational corporations and direct the development of the IT industry in India. The question that naturally arises is why the government chose a showdown strategy with IBM. Apparently, it did not originally set out to drive IBM away, but felt that it could not allow the corporation to be exempt from the FERA without jeopardizing the government's ability to negotiate with other multinationals and implement its nationalist policy objectives. One effect of IBM's departure was to open up the market to a number of competitors, including ECIL, ICL, and the Tata-Burroughs joint venture. ECIL dominated the market for a time thanks to strong government support, but by the end of the 1970s, local private firms had emerged to control most of the market. Table 6 shows the evolution of the computer market structure from 1960 to 1980.

The decline of ECIL was due partly to its own inability to produce competitive products but was exacerbated by changes in policy. The DOE had come under criticism in the late 1970s for blocking the efforts of private sector firms to produce hardware and for protecting ECIL at the expense of users and domestic competitors. The government responded by giving permission to several private companies such as HCL, DCM, and ORG to produce data processing systems and import parts and components. Soon these companies had supplanted ECIL as the major computer suppliers to the Indian market.

TABLE 6 *Computer Market Structure of India* (in percentage of total market)

<i>Company</i>	<i>1960-1966</i>	<i>1967-1972</i>	<i>1973-1977</i>	<i>1978-1980</i>
ECIL	0	3.4	40.3	10.2
HCL	0	0	0	40.5
DCM	0	0	0	27.5
ORG	0	0	0	7.3
IBM	73.8	73.1	3.1	0
ICL	4.7	11.7	9.9	2.1
Burroughs	0	0	2.6	2.6
DEC	0	0.7	25.1	3.6
Hewlett Packard	0	0.7	5.2	0.6
Honeywell-CII	0	8.3	1.0	0.2
Soviet	4.7	0.7	4.7	0

SOURCE: Adapted from Grieco, 1984.

NOTE: ECIL, Electronics Corp. of India, Ltd.; HCL, Hindustan Computers, Ltd.; DCM, Data Products; ORG, Operations Research Group; DEC, Digital Equipment Corp.; Honeywell-CII, Honeywell-Compagnie Internationale pour l'Informatique.

1980s: Partial Liberalization and Industry Promotion

India's IT policies in the 1980s were aimed at modernizing an industry that was estimated to be about 15 years behind the current frontiers of research and production.⁹ In a departure from the import substitution approach of the past, exports of software and peripherals were now promoted, and the imports of mainframes and supercomputers were encouraged under certain conditions. Some liberalization of trade and investment did occur, but there was no relaxation of the FERA restrictions on foreign investment, and tariffs remained in the 180-220% range. Two major policy initiatives were announced: the New Computer Policy of 1984 and the 1986 Policy on Computer Software Export, Software Development, and Training. The government also established a number of projects to promote IT production and use and develop infrastructure.

9. Eddie J. Girdner, "Economic Liberalization in India, The New Electronics Policy," *Asian Survey*, 27:11 (November 1987), pp. 1,188-1,204.

The new computer policy of 1984. A new computer policy was announced by the DOE in 1984¹⁰ aimed at promoting the manufacture of computers based on the latest technology, at prices comparable to international levels, and with progressively increased indigenization. It also attempted to promote the use of computers for economic and social development. An important policy change was the liberalization of imports to foster domestic hardware production. Duty levels were lowered on components needed by computer manufacturers, and companies producing CPUs, peripherals, and subsystems on an OEM (original equipment manufacturer) basis were permitted liberal imports of “know-how” with a low excise duty. Manufacture of micro- and minicomputers were permitted for any Indian company, removing existing licensing requirements. Domestic producers continued to be protected from foreign competition by tariffs in the 200% range, but duties were to be reduced over time. Another policy change was the elimination of maximum capacity restrictions, which had limited computer production to uneconomical levels. These were replaced by minimum capacity requirements, which actually promoted economies of scale in production.

To promote IT use, imports of designs, drawings, software, and technology were liberalized for manufacturers and R&D units in other sectors. Actual end users were allowed to import computers and subsystems, with virtually automatic approval for systems costing less than about US\$8,000. Nevertheless, the policy was limited and still within the bounds of an import-substituting, state-directed strategy of IT development. Domestic producers were still protected by very high tariffs and no changes were made in the equity limits on foreign investment. However, private producers had won some important concessions on imports and easier entry into the market.

1986 software policy. Following up on the 1984 hardware policy, the DOE announced the 1986 Policy on Computer Software Export, Software Development, and Training. The objectives were: to promote the integrated development of software in the country for domestic as well as export markets; and to promote the use of the computer as a tool for decision making and to promote appropriate applications that will catalyze economic development.

The software policy, dubbed by DOE’s N. Seshagiri as a “flood-in, flood-out strategy,”—allowing an initial flood-in of imports to achieve a greater flood-out of exports¹¹—is based on the belief that India has intrinsic

10. “New Computer Policy,” *Electronics Information & Planning*, 12:2, 1984.

11. “The New Software Policy: Dr. Seshagiri Clarifies,” *Dataquest*, January 1987, pp. 82–95.

sic economic advantages in the field of software in the form of human resources, and that promoting software production could provide a source of economic growth, foreign exchange earnings, and jobs. The software policy was a tacit admission that policies to protect domestic hardware producers were stunting the development of the software industry by denying programmers access to necessary hardware and to software development tools.

Under the policy, licensing requirements were removed on software imports and the duty was reduced to 60%. This was reduced in 1990 to 25% for computers and software used by software producers.¹² Previously, most popular software packages had not been allowed in the country at all. Also, firms setting up export-oriented software operations were allowed access to foreign exchange for the import of hardware and/or software in return for meeting export targets. In order to facilitate training of computer professionals, imports of hardware and software designed for computer aided instruction were allowed with a 60% duty. Foreign exchange was also made available for hosting foreign experts and importing training equipment. In 1990, a 100% income tax exemption was extended to profits from software exports and the double taxation of software imports (income and customs) was eliminated. Also, it was decided to develop twelve additional software technology parks.

Unlike India's hardware policies, software policies have not attempted to promote any particular companies or establish state enterprises. As Seshagiri put it, the policy is based on the idea that "there should be a free-wheeling condition . . . because we cannot anticipate . . . what kind of software is going to be dominant in the world two years hence." The government clearly sees the software policy as very liberal, and by past standards it is. But by international standards, a 60% import duty is hardly liberal, especially with export requirements attached. While the policy helped software exporters, it did little for companies developing products for the domestic market. Also, penetration of foreign markets is an expensive and risky proposition and the policy provided little direct support to exporters, such as market intelligence or export finance facilities.

*IT Industry Promotion*¹³

A number of programs, initiatives, and institutions have been established to implement policy and promote various aspects of IT. Five areas are especially important.

12. "Let Us Look at Electronics as a Means of Tackling Crises," *Computers Today*, January 1991, p. 63.

13. Background on IT industry promotion is primarily from N. Seshagiri, "Management of Technological Change: Information Technology in India," report prepared for the

Research and development. The DOE invests in IT R&D through large multiyear programs involving various research units. For example, the Knowledge Based Computer Systems (KBCS) program involves the five Indian Institutes of Technology, the Institute of Science in Bangalore, and the National Center for Software Technology (NCST) in Bombay. IT-specific R&D includes projects to develop software tools and train personnel in software concepts, develop prototypes of advanced architectures, and develop a Fifth Generation Computer. In addition, the Education and Research in Computer Networking (ERNET) experiments with new concepts in computer networking and promotes Integrated Services Digital Network (ISDN). These programs tend to be aimed at frontier technologies rather than more mundane efforts to assimilate imported technologies. The ability to engage in such advanced research is a tribute to the quality of Indian scientists, but the emphasis in that area may be questionable. Evidence from other countries, especially in East Asia, suggests that there are greater gains to be made from research aimed at adaptation of imported technologies than from basic R&D aimed at developing new ones.

IT networks. In 1988, the National Informatics Center set up NICNET, a satellite-based computer-communications network connecting 439 cities and towns. The network supports computerization of governments at the central, state, and district levels and in the public sector in general. A Computer Aided Design project has been set up with links to five centers, and a Computer Aided Management Infrastructure has been established with feeder centers in four cities. These network development efforts are pragmatic in orientation. NICNET is aimed at improving government services through computerization and networking of local governments, while the CAD/CAM projects are relevant to the needs of local industry.

IT use. A number of projects have been undertaken to promote IT use in the private and public sectors and to mobilize a favorable bias toward IT use. For instance:

- Demonstration projects have been initiated in such areas as CAD/CAM and computer networking.
- Government has promoted the use of IT applications in priority sectors such as cement, steel, coal, petroleum, power, telecommunications, and transport.
- Government has supported the creation of administrative databases in areas such as agriculture, irrigation, education, health, and public grievances.

- Pilot projects for new technologies or applications have been initiated in an organization in a given sector, and after successful implementation, the technology is transferred to other organizations.

Efforts also have been made to increase public awareness of IT. Computers have been introduced in visible public locations, including the computerized railway reservation system, airline reservation systems, electricity billing, and retirement benefit accounting. Despite these considerable efforts, there has been a notable lack of incentives, such as tax breaks or accelerated depreciation rules, to encourage private sector use. Most importantly, the high barriers to imports have acted as strong disincentives to the use of IT.

Government procurement. Sixty percent of all IT purchases in India are from government or the public sector, both of which are required to use indigenous sources when available. Government procurement is used to bring about technology changes and to support domestic producers.

IT skills. In 1983 the Programme on Development of Manpower for Computers was launched, and in the next five years the number of institutions conducting degree/diploma-level computer courses increased tenfold and the output of trained IT professionals grew from 1,000 to 10,000. New courses were introduced by the DOE in various computer skills, as well as schemes for training teachers and support for vocational courses in computers. Despite these efforts, from 1985 to 1990, only about 50% of the demand for computer personnel could be met due to shortages of teachers, lack of funds, and the brain drain of IT professionals.

India's IT policies have focused heavily on regulation of foreign as well as domestic producers and on protection of the domestic market. The 1984 and 1986 policies consisted mostly of loosening existing regulations, with only minimal attention given to improving the IT infrastructure or directly promoting IT production or use. The remaining trade and investment barriers are still a major obstacle to the diffusion of the technology. By maintaining high barriers to computer imports, the government has created a situation where it is most profitable for hardware makers simply to assemble imported components for resale. For software companies, the lack of access to hardware for programming and the small domestic hardware base has made it more profitable to send workers abroad to do contract programming rather than to develop programs at home.

The policies chosen in the past have often been driven more by broad political and economic considerations than by a desire to diffuse IT use and production broadly. The heavy emphasis on self-sufficiency was related to ideological and security concerns, while the 1980s push for software exports was largely due to balance-of-payments concerns. The

paucity of policies to improve the IT infrastructure is evidence of a lack of focus on long-term growth of IT use and production. Without the necessary human resources, telecommunications networks, research capabilities, and capital availability, India's potential as an IT producer and user remains limited.

IT Diffusion

Production

The Indian government's attempts to spur the development of an indigenous IT industry appear to have been quite successful in several respects. After the 1984 computer policy was announced, production shot up 100% while prices declined by 50%.¹⁴ On the other hand, from 1980 to 1982, before the policy was in place, production of computers had increased by over 300%. As Table 7 shows, sales of Indian computers soared in the 1980s, but there is no clear evidence that the growth rate was substantially affected by government policy initiatives. What probably caused the take-off was the decision to permit private sector companies to produce microcomputers, which corresponded to the introduction of the personal computer in the United States. It was thus possible for Indian producers to purchase components from abroad and assemble them into PCs for the local market. A boom in microcomputer sales began in 1986 when HCL dropped its prices dramatically, starting a price war that greatly increased the affordability of PCs in India. Price competition brought the prices of microcomputers down from about \$4,000 in 1986 to \$1,600 in 1987.¹⁵ The growth in production is impressive, and one may conclude that the policies implemented in the 1980s were beneficial in that they at least partially opened the industry to international technology. Also, policies have achieved a measure of indigenization in that the industry is dominated by Indian firms and firms with a majority of Indian equity, as seen in Table 8. Only ICIM and Digital Equipment are subsidiaries of MNCs. Figures such as these provide ammunition for those defending the Indian computer policy. However, critics point out that production of PCs and other hardware mainly consists of the simple assembly of imported components, which at times actually shows a negative value added as the cost of the components exceeds the value of the finished product.¹⁶ Local firms are growing rapidly but could not survive without high tariff protection.

14. DOE, "Policy on Computer Software Export, Software Development and Training," GOI, November 1986.

15. Arvind Singhal and Everett M. Rogers, *India's Information Revolution* (New Delhi: Sage Publications, 1989).

16. S. Reback, "A Backfired Policy," *Asian Computer Monthly*, July 1990.

TABLE 7 *Sales of Indian Computers*

	<i>Sales</i> (US\$ millions)	<i>Growth from</i> <i>Previous Period (%)</i>
1979-80	12	n.a.
1981-82	52	333
1983-84	96	85
1985-86	180	88
1987-88	370	105
1988-89	560	51
1989-90	930	66

SOURCE: *Dataquest*, 1987, in Singhal and Rogers, 1989, and *Dataquest*, 1990.

TABLE 8 *Top Ten Indian Computer Producers*

<i>Company</i>	<i>Sales (US\$ millions)</i>
HCL	102
CMC	69
Wipro	66
ECIL	53
Pertech	39
Tata Consultancy Services	36
ICIM (International Computers Indian Manufacture, Ltd., ICL subsidiary)	35
Sterling Computers	33
Digital Equipment (India)	20
Tata Unisys Ltd.	20

SOURCE: *Dataquest*, July 1990.

NOTE: Exchange rate: \$US1 = 18 rupees.

These firms depend on international linkages for technology and components, and while production is up and prices down, the Indian hardware industry is still mainly a screwdriver operation. And despite the government's plans to use kit assembly as a stepping-stone to indigenization, the high profits attainable from assembling imported components act as a disincentive to developing more integrated manufacturing capacity.

A major drawback to achieving international competitiveness is the fragmented nature of the industry. By 1988 there were 250 computer manufacturers in India, all competing for the small domestic market. As Table 8 shows, the largest had sales of only \$102 million. To achieve more efficient production levels and move down the learning curve more rapidly, Indian producers could consolidate into fewer firms, but existing policies discourage consolidation. Although the 1984 hardware policy removed production limits, the MRTP still restricts agglomeration that could allow one or a few firms to dominate the market. Another option would be to expand exports, but exporting is difficult and risky in the brutally competitive international market, while the protected domestic market offers more assured profits to local producers. India's IT hardware exports grew in the late 1980s, as Table 9 shows. However, much of this was due to exports to the Soviet Union, a market where Indian producers now face stiff competition from Western firms in the future as restrictions on computer exports to the former Soviet states are lifted. Realistically, India's potential as a hardware exporter is very limited. International competitive advantage depends mainly on technological and manufacturing capabilities, both weak spots for India.

Unlike the hardware industry, the Indian software industry has shown rapid growth in export production (see Table 10), and both Indian firms and multinational corporations are now developing software in India for international markets. The growth rate accelerated somewhat in 1986, coinciding with the 1986 software policy, although it is impossible to show a causal relationship between the two events. While the industry has clearly achieved notable export success, it is worth looking at the nature of the export sector. Currently, 70% of India's software exports come from "body-shopping," in which Indian programmers are sent abroad on a contract basis to write code for a foreign customer.¹⁷ This takes advantage of the wage differentials between India and the industrialized countries and gets around the infrastructure problems detailed above. However, as a long-term strategy, this has limited potential. Other countries are tightening up their immigration laws, making "body-shopping" more difficult; furthermore, many of the programmers stay in their host country to earn higher wages after completing their contract. Finally, much of the work done in this manner is low-value code writing, which is being replaced in some host countries by automated code generators.

Only a few local companies, such as Tata Consultancy Services, Wipro, and Infosys Consultants have had much success as exporters. The other

17. J. Ribiero, "Software Exporters Seek New Strategies," *Electronic Business Asia*, April 1992, p. 76.

TABLE 9 *Hardware Exports*

	<i>Exports</i> (in US\$ millions)	<i>Growth from</i> <i>Previous Year (%)</i>
1984-85	35	n.a.
1985-86	28	-20
1986-87	31	11
1987-88	42	35
1988-89	100	130

SOURCE: DOE, *Eighth Five Year Plan (1990-95), Electronics Industry*, 1989.

TABLE 10 *Indian Software Exports, 1980-1989*

	<i>Software Exports</i> (US\$ millions)	<i>Annual Growth</i> <i>Rate (%)</i>
1980	3	
1981	4	33
1982	10	150
1983	17	70
1984	22	29
1985	28	27
1986	38	36
1987	53	39
1988	71	34
1989	98	38
1990	128	31

SOURCE: DOE publications and NASSCOM.

big exporters are subsidiaries of foreign multinationals such as Texas Instruments and Citicorp. Some companies in other industries are also developing software export businesses to keep in-house programmers occupied and to earn foreign currency needed for imports. India's software industry has competed mainly on the basis of low-cost skilled professionals. However, this strategy is becoming less viable as the demand for programmers is driving up salaries. Over the last two years, salaries in the software industry have risen by 50%, according to a local

recruitment firm. In the future, the industry will have to emphasize quality and enter higher value-added markets such as systems design, systems integration, and packaged software. One advantage for Indian software firms is the country's development around open systems and its local experience in Unix. This offers opportunities for developing software with broad international market potential. Such development requires access to hardware and software tools compatible with the market. One way Indian software companies have gotten around the lack of these tools is by using satellite communications to link up to mainframes abroad. This requires that programmers be near the satellite ground station, since terrestrial links are not reliable or always capable of data transmission.

Developing export markets for packaged software also entails setting up overseas marketing networks, an expensive proposition. The government has begun to liberalize conditions for overseas investment, and state-owned CMC, Ltd., took over a U.S. software company in order to enter the U.S. market. But private sector exporters still complain of excessive red tape. Another critical issue for Indian software is piracy. Development for the domestic market is greatly hampered by the availability of pirated versions of most popular software packages. The 107% tariff on imported software greatly increases the temptation to pirate, often overcoming the benefits of having a legal copy (support, documentation, etc.). NASSCOM estimates that at least \$30 million worth of software sales were usurped by piracy in 1988-89.¹⁸ Software piracy has also damaged trade relations with other countries. The U.S. placed India on a priority watch list because of its failure to protect U.S. intellectual property rights, including computer software, and has twice cited India under Section 301 trade provisions. Capital is another requirement for developing a software industry. Banks are generally too conservative to invest in such a risky sector, and no software company is yet listed on any Indian stock exchange. While a company like Tata can draw on the resources of its large associated business house, some sort of venture financing facility needs to be developed for the smaller start-up companies.

Beyond the specific problems mentioned above, there is a larger concern about the heavy emphasis on export-led growth in the software industry. As Schware points out, there are strategic reasons for focusing initially on the domestic market to develop experience and capabilities before venturing into international markets.¹⁹ Producing for the domestic market al-

18. NASSCOM (National Association of Software and Service Companies), "Indian Software Industry 1990-95," report to National Software Conference '89, New Delhi, July 1989.

19. R. Schware, "Software Industry Entry Strategies for Developing Countries: A 'Walking on Two Legs' Proposition," *World Development*, 20:2 (1992), pp. 143-64.

lows companies to develop close ties with users who can provide valuable input into the product development process. Companies are also able to support export sales and R&D investments with revenue from the domestic market. Companies that rely on bodyshopping are vulnerable to competition from powerful international software firms and to mechanization of the programming process. They fail to develop project management capabilities or to develop applications that can be packaged and sold to a large number of users. It is difficult to institutionalize the knowledge and experience gained by programmers working abroad, so that knowledge is wasted if programmers leave the company. Previous IT policies have created incentives for bodyshopping and for MNCs to use India as an export platform, and they have created barriers to companies hoping to develop software for the domestic market. It may be that the new wave of economic liberalization will result in changes in IT policies. If so, the Indian software industry has tremendous potential for growth in both domestic and international markets.

IT Use

IT use in India has been growing rapidly since the mid-1980s. The total market in 1990 was \$959 million, and annual growth rates averaged over 20% for the five previous years. The distribution of the market by product category is shown in Table 11, and the level of IT penetration in India compared to that of other Asian countries can be seen in Table 12.

India's IT expenditures are slightly ahead of the other countries at similar levels of development—Indonesia and the Philippines—but it still falls well short of the levels of the East Asian NICs and Malaysia. PC penetration in India in terms of population is still very low. For example, Taiwan has one PC for about every 35 people, whereas in India the ratio is 1 for every 4,000. Assuming that PC use is almost entirely restricted to the 200 million upper and middle class Indians, penetration would be greater for that group, but it still is only about one PC for every 750 people. On the other hand, the growth rate of 20.3% per year outstrips that of any of the other countries except Korea at 25%. This growth is notable considering the numerous obstacles that still exist to IT use in India. Besides government regulations and poor infrastructure, there has been labor union opposition to computerization. There is also no widespread belief in the value of IT, and the lack of competition in the economy reduces the incentive to invest in new technologies.

Other barriers to usage are the price of equipment, usually two to two-and-a-half times the world price, and import barriers that have made some classes of equipment virtually unavailable. The export obligations placed on importers of computers make it almost impossible to import equipment

TABLE 11 *Indian IT Demand by Category, 1985-1990*

<i>Technology Sector</i>	<i>Spending for IT (in US\$ millions)</i>					
	<i>1985</i>	<i>1986</i>	<i>1987</i>	<i>1988</i>	<i>1989</i>	<i>1990</i>
Hardware	299	367	450	541	637	743
Software	32	36	49	64	77	91
Services	42	54	67	82	101	125
Total	373	457	566	687	815	959

SOURCE: Confidential industry sources.

TABLE 12 *IT Penetration in Asia-Pacific Countries*

	<i>IT Exp. as % of GDP, 1990</i>	<i>% IT Exp. Growth, 1985-1990</i>
Australia	2.44	10.8 (Aus/NZ)
New Zealand	2.25	
Hong Kong	1.51	19.1
Korea	1.06	25.4
Taiwan	0.97	18.1
Singapore	2.04	17.2
Indonesia	0.27	6.1
Malaysia	0.83	7.0
Philippines	0.34	17.3
India	0.40	20.3

SOURCE: Confidential industry sources.

for domestic use alone. Some companies have set up software divisions to write programs for their international operations, which allows them to show export earnings and thus be able to import hardware. Citicorp, for one, has become a substantial player in the software industry through such an operation. But for smaller companies without international operations, this is not a viable option, and they must either buy what the Indian companies make or do without.

It should be noted that in a country such as India, with great disparities in wealth, education, and standard of living, there is a legitimate concern that the adoption of IT will widen the gap between the social classes, creat-

ing a new division between "information haves and have-nots." Both the 1984 and 1986 policies mention the need to use information technology for development purposes, and to some extent this has been realized in the government's application of IT. NICNET, for example, provides access to computing for small government units throughout the nation. The government also purchased a Cray-XMP supercomputer to be used in weather forecasting, agriculture, health, molecular biology, and solid state physics. And the computerization of the railway reservation system has improved efficiency on a transportation system of vital importance to poorer Indians.

Conclusions

The focus of Indian industrial policy since independence has been achieving self-sufficiency through import-substituting industrialization and government ownership of key industries. In the IT sector, ideological and security concerns led to a focus on indigenization and technological self-sufficiency. In the 1970s, the government implemented heavy regulation and government production to achieve these goals, but by the early 1980s, India's computer industry was very small and still dependent on foreign technology. The policy changes of the 1980s were aimed at promoting growth of domestic hardware and software production, and resulted in some notable achievements. Hardware production and software exports grew rapidly. New products based on advanced technologies were introduced and hardware prices dropped significantly. Software companies overcame infrastructure problems and government restrictions on hardware imports through bodyshopping and employing satellite links to overseas hardware. However, these accomplishments are tempered by several other outcomes. Hardware production consists of assembling imported components with little value added. Software exports through bodyshopping fail to build domestic capabilities and often result in programmers staying in the other country after the job is finished. Both the hardware and software industries have more of a trading than a manufacturing mentality. And IT use has been limited by high tariffs and licensing requirements.

The reasons for this combination of outcomes can be found in the interaction of environmental factors and policy choices. For example, hardware policies protected the local market without requiring local content in domestic production or demanding that producers meet performance standards. In addition, the local electronics industry lacked the capacity to produce components for computers. Given this combination of policy incentives and environmental factors, local computer makers responded by assembling imported components and charging a premium price in the protected market. The software industry faced an environment in which

human resources were abundant, but infrastructure was poor. They also faced a set of hardware policies that denied them access to necessary tools, except for developing software for export. Given this situation, the industry developed a strong export bias based on shipping people rather than products, and has lagged in production for the domestic market. The international environment is also critical in an industry such as IT. The rapid technological change and falling prices for hardware worldwide made India's prospects for developing an export-oriented hardware industry, or catching up technologically, very dim. But the international shortage of programmers created an opportunity for India to capitalize on its abundance of programmers.

Policymakers must consider the broader picture when designing IT policy and treat it as part of an overall economic strategy in which sound economic policies will benefit the IT sector and the diffusion of IT will have positive effects on economic development and social welfare. If liberalization is to take place, it needs to have a positive agenda, as Evans points out, rather than just a negative agenda of reducing state intervention.²⁰ India's past experience and present resources, along with the experience of other developing countries, suggest some specific conclusions regarding future policy:

1. The greatest potential benefit of IT in India is in effective application of the technology to achieve economic and social development goals. There are tremendous gains to be made from the computerization of government, not only to improve delivery of existing services but to improve policy planning and implementation through more effective provision of information to policy makers. Local governments, small businesses, farms, and schools could use cheap microcomputers to gain access to distant information sources and improve their own operations. The government can facilitate this process by improving the communications infrastructure as it has done with NICNET, and by training people to use computers.
2. In the process of developing national information networks, the government could support the domestic IT industry. While it may be most cost effective to use foreign sources for sophisticated hardware, these projects also require software development and systems integration that are within the capabilities of Indian professionals. Working on such projects would enable local firms to develop a wide range of experience that could be applied to other projects, both at home and abroad. Along with liberalizing access to hardware and improving the communications infrastructure, this type of support could enable the software and systems integrations sectors to develop in a balanced, sustainable way. As Schwabe argues, producing for the do-

20. P. B. Evans, "Indian Informatics in the 1980s: The Changing Character of State Involvement," *World Development*, 20:1 (1992), pp. 1-18.

mestic market gives companies the skills and a strong financial basis for entering export markets. They will also have the capabilities to manage projects abroad or to develop packaged software for export, rather than depending on bodyshopping.

3. Hardware production in India should not be protected at a cost to users or the software and services industries. Given India's present endowments, it makes more sense to reduce tariffs and encourage hardware producers to move into other areas or link up with multinationals. Local content requirements for government procurement would provide incentives for MNCs to produce in India or work with India's producers. This could actually lead to higher value-added production in India and maintain the viability of some of the local hardware firms.

The present shift toward liberalization of the economy presents the possibility of major changes in IT strategy. Allowing 51% foreign ownership and reducing the level of bureaucratic red tape may encourage more multinational companies to utilize India's large and skilled labor pool, especially for software production. However, these changes are just a start, and it is not clear whether further reforms are forthcoming for the economy as a whole or the IT sector. There are compelling reasons for change but strong ideological and political barriers exist, and the present government holds a tenuous electoral position. Indian economic policy is in a time of transition, and it is unclear what the ramifications will be for IT policy.