Forthcoming in *Asian Survey*

India's Quest for Self Reliance in Information Technology: Costs and Benefits of Government Intervention

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I. INTRODUCTION

Information technology (IT) is one of the fastest spreading technologies in the world in terms of its use and production. IT use is ubiquitous in the industrialized countries, to the extent that in the U.S., 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. These include acting as leading users of IT, supporting research and development, and regulating and providing incentives to the private sector. While the U.S. government policies have generally been implemented on an ad hoc basis, the Japanese government has pursued a more coordinated strategy towards the development of IT.[1] 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 developing and

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1 For a detailed account of the Japanese government's policies to promote a domestic computer industry, see Marie Anchordoguy, Computers Inc.: Japan's Challenge to IBM (Cambridge, MA: Harvard University Press, 1990).

newly industrializing countries (NICs) have pursued government policies to promote domestic production and/or use of IT.[2]

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. Since the 1970s, the Indian government has 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 which can be achieved through government intervention, but also points out the limitations of government intervention and 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-eighties and Indian companies have come to market with leading products, such as 386-based PCs, soon after they were introduced in the industrialized countries.

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[2] A variety of policy approaches can be observed among the newly industrializing countries with regard to IT. 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 targetted 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.

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 application of IT to improve 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 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[3] have discussed various aspects of India's experience with information technology and its government policies toward IT. This paper builds on these analyses

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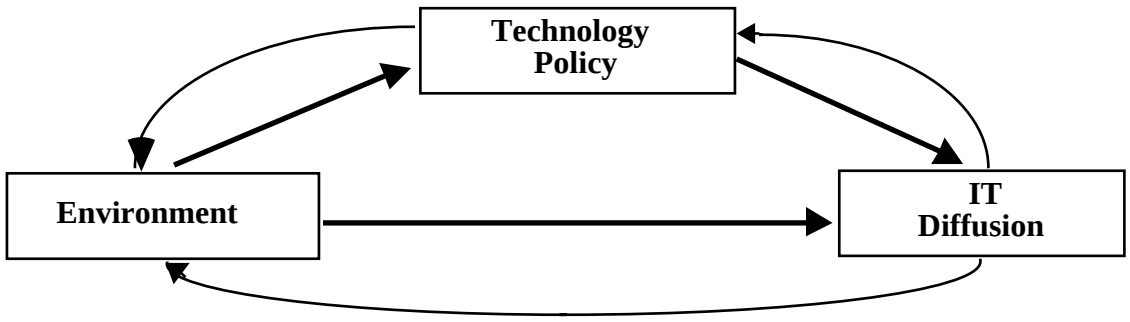
3 Hans-Peter Brunner, "Building Technological Capacity: A Case Study of the Computer Industry in India, 1975-87," *World Development*, Vol. 19, No. 12, pp. 1737-1751, 1991.; Robert Schware, "Software Industry Entry Strategies for Developing Countries: A 'Walking on Two Legs' Proposition," *World Development*, Vol. 20, No. 2, pp. 143-164, 1992.; Peter B.Evans, "Indian Informatics in the 1980s: The Changing Character of State Involvement," *World Development*, Vol. 20, No. 1, pp. 1-18, 1992.

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

This paper analyzes the role of government policy with respect to the diffusion of IT in India, but this 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 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.

Figure 1. Model for Research



The analysis of the Indian case is organized according to the contents of Figure 1: environment, technology policy; and IT diffusion.

II. ENVIRONMENT

Political and Economic Environment

Modern politics in India have been dominated by the desire to gain independence from the British, and then to remain independent from the major superpowers during the Cold War. Since independence in 1947, India has followed a generally socialist economic policy within a democratic political framework. Since 1991, however, the government of Prime Minister P.V. Narashimh Rao has instituted a number of market-oriented reforms which 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. In order to achieve rapid growth and national self-reliance, 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), who were invited into the country with few

restrictions starting in the late 1950s. 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 the economic power of large business houses (such as nationalizing the business house-controlled banks), they continued to grow, with Tata and Birla doubling their share of India's total private assets from 1963 to 1973.[4]

The predominance of the large business 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 efforts to limit the economic power of the major groups through the Monopoly and Restrictive Trade Policy (MRTP) Act of 1969. The MRTP Act required companies to obtain government permission to expand production or establish new capacity if the company 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 in India.[5] This was applied to the IT industry to limit the output of computer producers, and 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 multinational corporations. 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,

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

5 Balasubramanyam, 1984.

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. Government 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 neo-classical 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 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 has 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 which might threaten jobs and have supported the status quo regarding imports, since 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 Indian government that 35 years of inward-looking policies had not achieved rapid economic growth, self-reliance or a major improvement in 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. Gandhi's 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.

The reforms initiated were tepid at best, however. There was no effort to reduce subsidies for food and fuel, to make state-owned enterprises more productive, or to 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.[6] 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 $2 billion 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 laws, allowed state-owned enterprises to go out of business, or seriously

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6 P.N. Dhar, "The Indian Economy: Past Performance and Current Issues," in R.E.B. Lucas and G.F. Papanek (Eds.), *The Indian Economy, Recent Development and Future Prospects* (Boulder, CO: Westview Press, 1988).

reduced the size of the government bureaucracy. Such changes are considered necessary before foreign and domestic investment will increase substantially.[7]

Table 1. Growth in GNP per capita for selected Asia-Pacific countries

Country	1965-1980	1980-1988
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*

A broad indicator, composition of the workforce over time, is instructive of the evolution of the Indian economy.

Table 2. Percentage of workers in agriculture, industry and services

Percent of labor force in:	Agriculture	Industry	Services
1965	73.0	12.0	15.0
1985-87	62.6	10.8	26.6

Source: United Nations Development Program, *Human Development Report 1991*

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. His view is that the government really has a short term trading focus rather than a long term focus on building a manufacturing base. In fact, the computer industry provides evidence of this. Its practice of assembling imported components for final sale is closer to trading than manufacturing. Also, the practice of "bodyshopping," or sending programmers abroad on a contract basis shows a trading orientation.

IT Infrastructure

7 *(The) Economist*, "Freeing India's Economy," (May 23, 1992) pp. 22-23.

The assimilation of any new technology requires the presence of an infrastructure 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.

1. Human Resources

Human resources are a key to success in any high-technology sector such as IT. 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 which can be mobilized to achieve that goal. Table 2 provides a comparison of India's human resources with other Asia-Pacific countries.

Table 3. Human resource indicators for selected Asia-Pacific countries

	Adult Literacy*	Secondary Enrollment*	Education Exp. as % of GNP*	Number of Scientists and Engineers**	Scientists and Engineers per 10,000 population**
Australia	99%	96%	5.1	38,568	23.4
New Zealand	99	84	4.8	4,091	13.6
U.S.A.	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***	87***	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*****	*25*****

*United Nations Development Program, *Human Development Report 1990*
**Pacific Economic Cooperation Conference, Science and Technology Task Force, *Pacific Science and Technology Profile 1991*
*** Republic of China, *Statistical Yearbook of the Republic of China*, 1984

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

The number that immediately stands out in Table 3 is the number of scientists and engineers, 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.[8]

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 150 million people. It is this middle class that is the potential market for IT products, and 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 on for advanced study and careers in the U.S. and Europe.

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 every year of the plan period. The shortage of people is due partly to the fact that the educational system 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. In a study by IIT/Madras, it is 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 leaving to other countries where they can earn better salaries and find professional challenges unavailable in the Indian industry.[9]

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

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

Evidence of the caliber of these expatriates is the success of non-resident Indians (NRIs) in the U.S., where they are an important part of the Silicon Valley 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.[10]

The success of the NRIs is clear evidence of the high caliber of IT professionals turned out by Indian universities. The government has 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 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.

2. 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, as illustrated in Table 4.

Table 4. Number of telephones per 1,000 population

Country	Number
Australia	436
New Zealand	419
U.S.A.	520
Japan	403
Korea	209
Taiwan	262
Singapore	340
Hong Kong	360
Malaysia	68
Philippines	7
India	*5*

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

Source: Siemens, *International Telephone Statistics 1989*

In 1985, the government passed a new telecommunications policy, which 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.

3. 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 towards 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 technology do more R&D than those who don't.[11] This suggests that technology transfer stimulates, rather than replaces, domestic R&D, a finding which 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 (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.

Table 5. R&D expenditures for selected Pacific Rim countries

	R&D Expenditure as % of GNP(1988)	Business Exp. on R&D as % of total R&D
Australia	1.32	36.5
New Zealand	0.97	22.3
U.S.A.	2.66	70.3
Japan	2.85	66.0

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

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*

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 non-resident Indian scientists and engineers to return to India as entrepreneurs, a strategy which 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.

4. Capital

Savings equalled 22% of GNP in 1987, a rate comparable to most Western countries, although 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.

Comments

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. However, 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.

III. TECHNOLOGY POLICY

IT Policy History

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 production. Another era may now be in the making, as the government moves towards more extensive liberalization of the economy.

1. 1960s and 1970s: Indigenization and self-sufficiency[12]

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 which devised 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 eventually to achieve 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 which 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 1960-1972, 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. IBM said it would leave India 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 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 government’s 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

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

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 effectively regulate the MNCs was due partly to institutional weaknesses in the agencies assigned the task. In 1966, 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. However, the committee lacked support staff and had no authority to compel action by other agencies. This lack of authority and technical competence left the government unable to negotiate with the MNCs or to regulate the IT sector effectively.

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 and a new Electronics Commission. The Commission was responsible for policy formulation and oversight and the Department was responsible for day-to-day implementation of policies.

The Electronics 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 effectively regulate the sector. In 1975, the Department of Electronics was given power over the licensing of computer imports. The new 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 minicomputer 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 which could be delivered on time.

The third and most important action taken by the Electonics Department and Commission was to once again challenge 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 occured. In 1975, 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 the government 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. Now users would 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 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 which naturally arises is why the government chose a showdown strategy with IBM. It seems that the Indian government did not originally set out to drive IBM away, but felt that it could not allow IBM to be exempt from the FERA without jeopardizing its ability to negotiate with other multinationals and implement its nationalistic 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 such as HCL, DCM and ORG had emerged to control most of the market. Table 6 shows the evolution of the computer market structure from 1960 to 1980.

Table 6. Computer Market Structure of India (percentage of total market)

Company	1960-1966	1967-1972	1973-1977	1978-1980
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

The decline of ECIL was partly due to its own inability to produce competitive products, but it 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.

2. 1980s: Partial liberalization and industry promotion

India's IT policies in the 1980s were aimed at modernizing an industry which was estimated to be about 15 years behind the current frontiers of research and production.[13] 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 in the 1980s, 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.

The New Computer Policy of 1984

13 Eddie J. Girdner, "Economic Liberalization in India, The New Electronics Policy," *Asian Survey*, Vol. XXVII, Vo. 11, November 1987, pp. 1188-1204.

A new computer policy was announced by the Department of Electronics in 1984,[14] 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 basis were permitted liberal imports of "know-how" with a low excise duty. Manufacture of mico- and minicomputers was permitted to 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. Imports of computers and subsystems were permitted to actual end users with virtually automatic approval for systems costing less than about $US 8,000.

While the policy provided for some liberalization, it 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.

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14 *Electronics Information & Planning*, "New Computer Policy," Vol.12, No. 2, 1984.

1986 Software Policy

Following up on the 1984 hardware policy, the DOE announced the 1986 Policy on Computer Software Export, Software Development and Training (Department of Electronics, 1986). The objectives of this policy were:

- To promote the integrated development of software in the country for domestic as well as export markets.
- To promote the use of the computer as a tool for decision making and to promote appropriate applications which will catalyze economic development.

The software policy is dubbed by DOE's N. Seshagiri as a "flood-in, flood-out strategy," i.e. allowing an initial flood in of imports to achieve a greater flood out of exports.[15] It is based on the belief that India has intrinsic 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.

The software policy provided easier access to necessary hardware and software. 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.[16] 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

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15 *Dataquest*, "The New Software Policy: Dr. Seshagiri Clarifies, January 1987, pp. 82-95

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

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 taxes) was eliminated. Also, it was decided to develop 12 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 puts 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 it is, by past standards. But by international standards, a 60% import duty is hardly liberal, especially with export requirements attached. While this liberalization 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 (e.g., market intelligence, export finance facilities).

IT Industry Promotion[17]

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17 Background on IT industry promotion primarily from N. Seshagiri, "Management of Technological Change: Information Technology in India, report prepared for the Commonwealth Secretariat Commonwealth Fund for Technical Cooperation,1988; and Department of Electronics, *Report of the Working Group: Eighth Five Year Plan (1990-95), Electronics Industry*, (New Delhi: Government of India, 1989).

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

1. Research and Development

The DOE invests in IT R&D through large multi-year programs involving various research units. For example the Knowledge Based Computer Systems (KBCS) program involves the five IITs, 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, to develop prototypes of advanced architectures, and to develop a Fifth Generation Computer. In addition, the Education and Research in Computer Networking (ERNET) experiments with new concepts in computer networking and promotes ISDN.

These R&D 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 the East Asians, 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 technologies.

2. 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. Also, a Computer Aided Design project has been set up with links to five centers, while 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.

3. Promoting 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 towards IT use. For instance:

- Demonstration projects have been initiated in areas such 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 one organization in a given sector and after its successful implementation, the technology is transferred to other organizations.

Efforts were also made to increase public awareness of IT. Computers have been introduced in locations visible to the public. These include the computerized Railway Reservation System, airline reservation systems, electricity billing, and retirement benefit accounting.

Despite these considerable efforts to promote IT use, 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.

4. Government Procurement

60% 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.

5. IT Skills

In 1983, the Programme on Development of Manpower for Computers was launched. Between 1983 and 1988, the number of institutions conducting degree/diploma level computer courses increased tenfold, while the output of trained IT professionals grew from 1,000 to 10,000. New courses were introduced by the DOE in various computer skills. DOE also introduced schemes for training teachers and supports 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.

Comments

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 to simply 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 developing programs at home.

The policies chosen in the past have often been driven by broad political and economic considerations more 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 is still limited.

IV. 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 regards. After the 1984 Computer Policy was announced, production shot up 100% while prices declined by 50%.[18] 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 takeoff was the decision to permit private sector companies to produce microcomputers, which corresponded to the introduction of the personal computer in the U.S. 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 it prices dramatically, starting a price war which greatly increased the affordability of PCs in India. Price competition brought the prices of microcomputers down from about US$4,000 in 1986 to US$1600 in 1987.[19]

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18 Department of Electronics, "Policy on Computer Software Export, Software Development and Training," Government of India, November 1986.

19 Singhal and Rogers, 1989.

Table 7. Sales of Indian computers

	Sales (US$ millions)	Growth from previous period (%)
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

Sales: *Dataquest*, 1987, in Singhal and Rogers, 1989 and *Dataquest*, 1990; Exports: DOE 1989

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.

Table 8. Top 10 Indian Computer Producers

Company	Sales (US$ millions)
HCL	102
CMC	69
Wipro	66
ECIL	53
Pertech	39
Tata Consultancy Services	36
ICIM (ICL subsidiary)	35
Sterling Computers	33
Digital Equipment (India)	20
Tata Unisys Ltd.	20

Exchange rate: $US1=18rupees
Source: *Dataquest*, July 1990

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 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.[20] Local firms are growing rapidly, but could not survive without high

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

tariff protection. 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,[21] all competing over the small domestic market. As Table 8 shows, the largest had sales of only US$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 which 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 will 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.

Table 9. Hardware Exports

	Exports	Growth from

21 Singhal and Rogers, 1989.

	(in US$ millions)	previous year (%)
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

Unlike the hardware industry, the Indian software industry has shown rapid growth in export production, as seen in Table 10. 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.

Table 10. Indian Software exports, 1980-1989

	Software Exports (US$ million)	Annual Growth Rate (%)
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

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.[22] 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. Also, many of the programmers stay in their host country after completing the job to earn higher wages. Finally, much of the work done in this manner is low-value

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

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 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 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.[23] 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.

Another requirement for developing a software industry is capital. 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-ups.

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[24], there are strategic reasons for focusing initally on the domestic market to develop experience and capabilities before venturing into international markets. Producing for the domestic market allows 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 which 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 which can be packaged and

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

24 R. Schware, "Software Industry Entry Strategies for Developing Countries: A 'Walking on Two Legs Proposition," *World Development*, Vol. 20, No. 2, pp. 143-164, 1992.

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. 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:

Table 11. Indian IT demand by category, 1985-1990

Technology Sector	Spending for IT in US$ millions 1985	1986	1987	1988	1989	1990
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

The level of IT penetration in India compared to that of other Asian countries can be seen in Table 12:

Table 12. IT penetration in Asia-Pacific countries

	IT exp. as % of GDP, 1990	% IT exp. growth, 85-90
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

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 newly industrialized countries and Malaysia. PC penetration in India in terms of population is still very low. For example, in Taiwan, there is 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 150 million upper and middle class Indians, penetration would be greater for that group, but still only about 1 PC for every 750 people.

On the other hand, the growth rate of 20.3% per year outstrips any of the other countries except Korea at 25%. This growth is especially notable considering the numerous obstacles which still exist to IT use in India. Besides government regulations and poor infrastructure, there has been labor union opposition to computerization. Also, there is 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 2 to 2 1/2 times the world price, and import barriers which have made some classes of equipment virtually unavailable. The export obligations placed on importers of computers makes it almost impossible to import equipment 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, creating a new division between "information

haves and have-nots." Both the 1984 and 1986 policies mention the need to use IT 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.

VI. 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 which 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 policy 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, as Evans points out[25], to have a positive agenda, rather than just a negative agenda of reducing

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25 P.B. Evans, "Indian Informatics in the 1980s: The Changing Character of State Involvement," *World Development*, Vol. 20, No.1, pp.1-18, 1992.

state intervention. 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 policymakers. Local governments, small businesses, farms and schools could use cheap microcomputers to gain access to distant information sources and to 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 which 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 Schware argues, producing for the domestic 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 developed 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 to 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 possibilty of major changes in IT strategy as well. 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 if further reforms are forthcoming for the economy as a whole or the IT sector. There are compelling reasons for change, but strong ideological and politcal 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.

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Acknowledgements

This paper is a product of research supported by the University of California Pacific Rim Program, National University of Singapore, and IBM World Trade Asia Corporation. The authors would like to acknowledge Vijay Gurbaxani for assistance in developing the case study. They would also like to thank K.K. Krishnan Kutty, G.R. Mohan Rao, Pronab Sen, N. Vittal and N. Seshagiri for their insights provided in interviews and in comments on an earlier draft. The facts and interpretations presented herein remain solely the responsibility of the authors.