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Globalizing Information Technology: The Domestic Policy Context for India's Software Production and Exports

Balaji Parthasarathy
Indian Institute of Information Technology, Bangalore

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Abstract: This essay explains how the domestic policy context enabled the Indian software industry to become the largest non-OECD (Organisation for Economic Co-operation and Development) exporter by 2000. The policy context is examined in three phases. Prior to 1984, rigid policy restrictions ensured that there was virtually no software industry. In the second phase (1984 to 1990), the restrictions were eased and Indian firms entered the global market by providing low-cost programming services. In the third phase (1990 to 2000), pro-active promotion of the industry, along with economy-wide policy liberalization, led to rapid growth in exports. The nature of exports also changed from providing programming services at client sites, to providing offshore services from India for turnkey projects demanding a wider range of capabilities. The policy changes themselves are explained in terms of the changing character of state institutions. The essay also discusses the relevance of the Indian case for policy initiatives in other countries.

Keywords: Globalization, India, Software Services, Public Policy, Software Industry

The Indian software industry has grown rapidly since the 1980s, with revenues increasing from less than $100 million in 1985-86 to nearly $8.4 billion by 2000-01 (Figure 1). During this period, exports grew even faster, with their share increasing from less than a third to nearly three quarters of revenues. This essay will analyze the domestic conditions under which this export-led industry has grown. Although global demand for software, sustained by the PC, networking and internet revolutions of the 1970s, the 1980s and the 1990s respectively, played an important role in facilitating the growth of the Indian industry, it was also available to

other countries. Similarly, while India offers a highly skilled, English-speaking workforce whose wages are much lower than that of the US (Figure 2), India's main software market,[1] India is hardly unique in possessing such labor force characteristics. Indeed, global demand and the availability of a high-skill, low wage workforce are necessary, but not sufficient, conditions. If they were sufficient conditions, one must explain why India failed to take similar advantage, unlike her East Asian counterparts such as Taiwan, South Korea and increasingly China, of the globalization of semiconductor design and manufacturing since the 1960s.[2] In other words, the growth of India's software industry must be explained in terms of how shifting domestic policy conditions allowed her to take advantage of global demand and her labor force characteristics to become, along with Israel, the leading non-OECD software exporter by the end of the millennium.

YEAR	REVENUES (IN MILLIONS OF US$)	EXPORTS AS % OF REVENUES	EXPORTS AS % SHARE OF STPS
1985-86	81	29.63	
1986-87	108	36.11	
1987-88	130	40.00	
1988-89	160	41.88	
1989-90	197	50.76	
1990-91	243	52.78	
1991-92	304	53.95	
1992-93	388	57.99	8.0
1993-94	560	58.93	12.0
1994-95	787	62.13	16.0
1995-96	1253	60.18	29.0
1996-97	1841	59.75	46.0
1997-98	3011	58.42	54.0
1998-99	4069	63.90	58.0
1999-00	5611	70.61	68.0
2000-01	8386	74.14	

Figure 1. India's Software Revenue and Exports, 1985-86 to 2000-01. *Sources:* www.nasscom.org; National Association of Software and Service Companies (NASSCOM), *Indian Software Directory, 1993-94,* (New Delhi: NASSCOM, 1993); National Association of Software and Service Companies (NASSCOM), *Indian Software Directory, 1992,* (New Delhi: NASSCOM, 1992); STP data from www.stpi.soft.net.

India's software exports, however, did not grow uniformly between the mid-1980s and 2000. A statistical analysis showed that, between 1987 and 1992-93, a linear equation provides the best fit for the growth trend.[3] From 1992-93 (and up to 1994, the last year for which there was data), however, an exponential equation provided a better fit, though there were

insufficient data points to determine whether that was a long-term trend. But it was projected that if exports maintained the exponential trend, they would amount to $630 million by 1997. Since India's software exports in 1996-97 were $997 million, the trend was clearly exponential. Using this data analysis as a starting point, this essay will examine why exports behaved the way they did from the mid-1980s on: in other words, why they "followed a linear trend in a world that tends to behave exponentially," before there was "a substantial change in the behavioral attributes of the software export sector."[4]

JOB TITLE	USA	INDIA
Project Leader	$65,600	$33,700
Systems Analyst	58,300	20,500
Systems Designer	66,900	16,100
Development Programmer	49,800	11,700
Support Programmer	45,000	11,700
Network Analyst/Designer	59,600	20,500
Quality Assurance Specialist	60,800	20,500
Database Data Analyst	60,800	24,900
Metrics/Process Analyst	58,300	24,900
Documentation/Training Staff	43,800	11,700
Test Engineer	57,100	11,700

Figure 2. Average Annual Software Labor Cost in US Dollars (1999). *Source:* International Labor Organization (ILO), *World Employment Report 2001: Life in the Information Economy* (Geneva: ILO, 2001), p. 135.

The changed growth characteristics of India's software exports have also been accompanied by certain qualitative shifts. While India's exports mostly involve the provision of software services (Figure 3), during the 1990s, there was a gradual shift away from onsite service provision, which involves sending employees to work at client sites overseas, to offshore service provision, which refers to developing and exporting software from India. This essay will explain how policy changes facilitated the quantitative expansion of software exports and shifts in the spatial organization of exports. But explaining why the export of software products and packages has remained relatively insignificant is beyond the scope of this essay.

The first section of this six-section essay will introduce the key institutions, especially the Department of Electronics (DoE), responsible for policy making for the computer industry. Until 1978, a scientific establishment staunchly committed to indigenous technology and self-reliance dominated the DoE. The highlight of this period was the unsuccessful effort to promote a public sector "national champion" in the

computer industry after ousting IBM. Section 2 describes how the policy environment ensured that there was really no software industry to speak of until 1984, despite efforts to develop software for locally manufactured computers, and a series of programs to encourage software export by providing easy access to imported computers.

YEAR	ONSITE SERVICES	OFFSHORE SERVICES	PRODUCTS & PACKAGES
1990	90.00	5.00	5.00
1993-94	62.01	30.05	7.94
1994-95	60.90	29.59	9.51
1995-96	60.32	31.63	8.05
1996-97	58.69	30.21	11.10
1997-98	59.00	32.20	8.80
1998-99	58.18	33.91	7.91
1999-00	57.26	34.69	8.05
2000-01	56.09	38.62	5.29

Figure 3. Sources of India's Software Export Revenues, 1990-2001 (as a percentage of export revenues). *Source:* www.nasscom.org; National Association of Software and Service Companies (NASSCOM), *Indian IT and Software Services Directory, 2001,* (New Delhi: NASSCOM, 2001).

Though the ineffectiveness of autarkic policies became apparent by the late 1970s, Section 3 will describe why a policy departure had to wait until Rajiv Gandhi took office as Prime Minister (PM). A few reform-minded bureaucrats used the political backing to redefine the role of the DoE and its policies to support the growth of the computer industry in the private sector. They were keen that the opportunities provided by the globalization of the computer industry not bypass India, as was the case with other sectors of the electronics industry. Thus, the Computer Policy of 1984 eased the availability of microcomputers and facilitated software exports by encouraging on-site service provision. The 1986 Software Policy encouraged foreign investment in the industry and access to technological developments overseas, by allowing easy imports of the latest software and software tools.

While the 1984 and 1986 policies mainly removed hurdles before the industry, positive promotion came in 1990 when the DoE initiated the Software Technology Park (STP) scheme after doing battle with other government departments such as the Department of Telecommunications (DoT), as Section 4 will describe. The STPs provide data communication facilities using which firms can provide offshore services from India instead of being limited to on-site provision. Since the sweeping economy-wide policy changes of 1991, various tariffs have been reduced and

procedures simplified to further help domestic firms and to attract a large number of transnational corporations (TNCs).

Section 5 will describe some of the characteristics of the Indian software industry that emerged from the policy changes since 1984. Although Indian firms entered the global market in the 1980s by offering sought-after expertise, the expertise was deployed primarily toward low-value added programming services at client sites. The rapid growth in exports in the 1990s followed the commissioning of the STPs that permitted firms to shift to offshore service-provision and work profitably with skilled labor at home. Further, Indian firms combined state-of-the-art infrastructure and production processes at their offshore development centers (ODCs), with well-developed project management abilities to obtain turnkey jobs that went beyond low-value-added programming services. A few also began converting experience gained in specific application areas into generic products. In the 1990s, a number of TNCs were also attracted to India by the quality of skills. After an early trickle of TNCs in the 1980s proved that India could be more than a low-wage hunting ground, the ODCs established by TNCs in the 1990s began to undertake work similar to their parent bodies.

The essay will conclude by highlighting the key shifts in policies and how they the facilitated the transformation of India into a significant software exporter. The conclusion will also examine the lessons that the Indian case offers for other newly industrializing countries (NICs) seeking to encourage the production and export of software.

The Origins of Policy-Making in the Computer Industry

Though the first electronic computer arrived in India in 1955, the origins of a computer policy dates to August 1963 when the Committee on Electronics was established following India's defeat in the war with China the previous year.[5] The chairman of the committee was Homi J. Bhaba, a nuclear scientist who was also the chairman of the Atomic Energy Commission (AEC). Since electronics was perceived to have a strategic role in national development and security, the Bhaba committee, as it was widely referred to, recommended ways to strengthen the technological base in electronics in the country. In its report submitted in February 1966, the committee argued that computers were playing an increasingly important social and scientific role. It also constituted a Working Group on computers under Prof. R. Narasimhan of the Tata Institute of Fundamental Research (TIFR), Bombay, an institution controlled by the AEC. The Working Group, in its 1968 report, called for a national effort to attain self-sufficiency within 10 years in small and medium computers. In calling for the development of across-the-board design and manufacturing capabilities, the report also argued that,

> A computer system is only as versatile as the software that is made available with it. . . . Software is business. Software is strategic. Thus it would be very foolhardy if a programme for the manufacture of the computer systems . . . does not have built into it a scheme for the development of appropriate software. . . . Software development can be farmed out to other organizations . . . this is also a labour intensive activity except that it requires intellectually skilled manpower. . . . Software development would seem to have very high employment potential in a country like India . . . the export potential, as well as the value added in the case of software, is very large.[6]

Initially, policy-making was in the hands of the Electronics Committee of India. The Committee was set up in November 1965 after the US cut off the supply of electronics equipment during the war with Pakistan that year. Given the circumstances, the committee was dominated by the Defense Ministry's Department of Defense Supplies. Since the Electronics Committee lacked the finances and the staff to implement policy, the DoE was established in June 1970, reporting directly to the Prime Minister. In February 1971, the Electronics Commission (EC) replaced the Electronics Committee as the primary policy making body.[7] M.G.K. Menon, a solid-state physicist and earlier director of TIFR, was the first chairman of the EC and Secretary DoE. Apart from Menon, the other members of the EC were the Cabinet Secretary, the Secretaries of the Finance Ministry and the Planning Commission, and the chairman of the public sector enterprise Electronics Corporation of India (ECIL).

With Menon in charge of the new institutions, control of electronics policy making in the country effectively shifted from the Defense Ministry to the scientific community, most of whom were drawn from the atomic energy program. For instance, Ashok Parthasarathi, who became the Secretary, EC, was drawn from the AEC, and N.Seshagiri, who headed the EC's Information, Planning and Analysis group, came from TIFR. This shift in control of the EC and DoE also resulted in a shift in policy emphasis. The defense establishment had been keen on ensuring access to electronics and computers. Thus, in the 1960s, it allowed IBM and International Computers Limited (ICL) to operate in India, though IBM's Indian operations were mostly limited to reconditioning and leasing obsolete 1401s. IBM went on to dominate the Indian computer market until the early 1970s, controlling nearly 75 percent of the market.[8]

In contrast, the scientific establishment was technologically ambitious and committed to self-sufficiency and self-reliance. This fit well within the larger economy-wide policy framework in place between the 1950s and the early 1980s. To meet the policy objective of building a broad-based indigenous industrial capability, this period witnessed the implementation of a heavy industry based, import substitution led industrialization (ISI) strategy in which a vast network of public sector enterprises (PSEs) was given the pride of place.[9] The private sector was often barred from operating in the sectors where PSEs had a presence, although both PSEs

and private sector firms were hampered by a highly restrictive and discretionary licensing regime in which state sanction for virtually all aspects of their operation, be it production capacity, plant location or credit and foreign exchange needs, was mandatory.[10] The policy regime not isolated the Indian economy from the world, and stifled entrepreneurship and innovation. It also hindered the growth of the electronic computer industry and prevented India from taking advantage of the emerging international division of labor in the semiconductor industry. Thus, until the early 1980s, the overall policy framework and the commitment of the DoE's leadership constrained the development of computing in India.

The PSE charge in computing was lead by ECIL. Originally established by the Department of Atomic Energy (DAE) in 1967 in Hyderabad to manufacture instrumentation for nuclear plants, it was promoted as India's "national champion" in the computer industry. ECIL started its computer manufacturing efforts by producing a 12 bit machine, the TDC-12. In 1974, it released a more advanced version of the machine, the TDC-312, and a 16 bit machine, the TDC-316. The development of these computers also resulted in the first significant attempt to write software on a commercial basis in the country. To develop the software, ECIL assembled a team of 100 engineers and supplemented their efforts by awarding contracts to TIFR, the Indian Institute of Management, Ahmedabad, the Indian Institute of Science, Bangalore, and the Administrative Staff College of India, Hyderabad.

But writing all the software from scratch, including the operating system, compilers and applications, proved to be a formidable task. The lack of adequate software severely limited the uses to which ECIL's computers could be put. Though custom packages were developed for several applications including data acquisition systems for the DAE, and data loggers for the steel industry, there were few applications for electronic data processing (EDP). ECIL did develop E-COBOL, its own version of COBOL. But, being a non-standard language, E-COBOL was not widely used. Thus, of the 208 TDC-12, TDC-312 and TDC-316 computers that ECIL sold until 1986-87, only 18 were purchased by the private sector.[11] The rest went to government departments, PSEs and universities. In contrast, of the 154 IBM machines installed until May 1978, more than 50 were in use in the private sector.[12]

In light of the experience with the 12 and 16 bit machines, it was clear that ECIL lacked the resources to develop its 32 bit machine, the System-332, on its own. It therefore imported a French computer, the IRIS-55, and resorted to reverse engineering. The idea was that if the machine served as a model for hardware design, ECIL would not have to develop software

for it. But the IRIS used unfamiliar technology and it was compatible with neither ECIL nor IBM machines.

Despite the problems, ECIL had displaced IBM as the leading player in the domestic market by 1972, after the EC had forced the latter to abandon the sales of its reconditioned 1401 machines. The DoE also began pressurizing IBM and ICL to move away from trading and to make a commitment to manufacturing more up-to-date systems locally, for the domestic market as well as for export. Further, since IBM's presence in India was through a 100 percent subsidiary of the parent company, it fell within the purview of the Foreign Exchange and Regulation Act, 1974. The Act disallowed foreigners from holding more than 40 percent equity in any firm in India. A higher stake of 74 percent was allowed only when technologies unavailable in India were involved. IBM proposed to the government that it would set up a 100 percent export unit to manufacture peripherals and another unit to export software worth about a million dollars annually. In return, it wanted to import computer systems up to 80 percent of the value of exports, besides retaining 100 percent equity in its core manufacturing, marketing and maintenance operations. But the equity issue proved non-negotiable. In contrast to ICL, which stayed on the government's terms, IBM shut its Indian operations in June 1978.

Promoting Software Exports before 1984

Although IBM's proposal fell through, the government made other efforts to promote software exports. The primary means was to permit the import of computers in exchange for a guarantee to export a certain amount of software. In any case, with the decline in IBM's sales, and the DoE stalling the licensing of manufacturers other than ECIL, despite recommendations to the contrary in the Microcomputer Panel Report of September 1973, imports were the only option. Unless, of course, somebody wanted to wait 18-24 months for a ECIL computer costing significantly more than comparable international models.[13]

As early as in September 1970, the DoE issued newspaper advertisements inviting proposals for developing software, especially for export. But the response was poor. In 1973, the government established the Santa Cruz Electronics Export Processing Zone (SEEPZ) in Bombay. Guidelines issued in 1974 stated that computer time for exports would be guaranteed on a non-profit basis at the government's Regional Computer Centers.[14] New computers could be imported provided there was no foreign collaboration involved and the net foreign exchange earned within a five-year period equaled the amount spent on the import. The export requirements were later increased to 200 percent of the cost of the system. Tata Consultancy Services (TCS), Bombay, was the first company to export software under these guidelines. In 1977, the Tatas went into

partnership with Burroughs to establish a unit in SEEPZ to export software and peripherals. Money from the exports would pay for the import of Burroughs mainframes into the domestic market.

In July 1976 the government announced a programs to encourage non-resident Indians (NRIs) to invest in India.[15] Under the program, software firms could be established with imported computers with an export commitment equal to 100 percent of the value of the computer. Customs duties on hardware imports were also reduced in 1976 from over 100 percent to 40 percent. While duties were reduced, guidelines for the import of computers costing more than Rs.500,000 (US$ 56,000) were elaborate.[16] Importers had to follow a five-step procedure. It began with submitting an application listing the functional specifications of the computer and the applications for which it would be used. This was scrutinized by the DoE to determine whether or not the requirement could be met domestically. If the request was approved, tenders were placed. A commission of experts appointed by the DoE then evaluated the tenders and a final decision was made with input from the user. Before placing the order, a letter from the concerned state government stating that the interests of labor would not be hurt was required, as was a final nod from an approval committee chaired by the EC Chairman. These cumbersome guidelines led to delays and, in a study of 82 cases, it was found that it took anywhere between 6 to 64 months to procure the computer after the initial application was made.[17]

Despite the tedium of the procedure, 441 computers of various makes were imported between 1976-77 and 1980-81[18] in contrast to the 35 computers that were approved for imports between 1970 and 1975.[19] But exports did not grow, partly because of the difficulties in importing computers and software tools, and because of problems with obtaining foreign exchange for overseas marketing and business expenses. Efforts at tapping East European markets by sending government delegations were not fruitful either.

It was also found that many who had imported systems either evaded their export obligations or stopped exporting once they had fulfilled their obligations. Instead, they established service bureaus to lease out computer time in the domestic market. The establishment of service bureaus (and the jump in computer imports) not only reflected unmet demand in the country, but it also marked the beginnings of a software industry in the private sector. Following IBM's departure, many of its former employees established the service bureaus before shifting to software development.

Other developments also increased the local availability of computers. In 1978, S.R.Vijayakar was made Managing Director of ECIL and, in

December, Prof. B.Nag took over from Menon as Chairman EC and Secretary DoE. Neither Vijayakar nor Nag had any links to the atomic energy network and were not as committed to the idea of self-reliance and protecting ECIL. In any case, even before Menon's exit, there was growing disenchantment with ECIL. Pressure for policy changes began to mount from users and from other firms wanting to enter the market.

In response, the Minicomputer Policy of 1978 permitted the setting up of systems engineering companies to design and assemble computers. The permission was not without restrictions: no foreign financial or technical collaboration was allowed; annual production was limited to Rs.20 million (US$ 254,000), no more than five different types of systems could be produced and none of them could cost more than Rs.300,000 ($38,000). Despite the restrictions, four firms quickly established themselves to produce microcomputers, incorporating advances in microprocessor technology. By listing their products as accounting and invoice machines, these firms captured about 75 percent of the total computer market between 1978 and 1980. ECIL's share in the same period fell to 10.7 percent from approximately 50 percent between 1973 and 1977.[20]

The availability of computers was further eased when the Import Policy of 1983-84 permitted the duty-free import of computers costing less than Rs.500,000 (US$ 50,000). It also became easier to import completely knocked down (CKD) and semi knocked down (SKD) kits. As the cautious liberalization of the early 1980s increased supply and the exposure to computers, the demand for hardware and software grew. Despite more liberal tendencies in the domestic market, the DoE was concerned about the misuse of the computer import for software export program. Though it was the DoE that authorized computer imports, the Chief Controller of Imports and Exports (CCI&E) was responsible for monitoring export performance. There was an information gap between the two agencies that, from the DoE's viewpoint, encouraged misuse.

The recommendations of the Rajaraman committee became the basis for a tighter policy in 1981. The committee argued that since a relatively large number of computers had been imported in previous years, exporters should utilize spare computer capacity in the country wherever possible. If the DoE determined that no domestic capacity existed, import proposals would then fall under one of 3 categories: (A) Indian nationals who required foreign exchange from the government could import if they had a firm order for at least 20 percent of the value of the computer. They also had to export 200 percent of the value of the computer over a five-year period. (B) Similar conditions applied to NRIs who did not need foreign exchange. The only difference was that their export obligation over a five-year period was limited to 100 percent of the computer's value. (C) Indian nationals could import against a specific export order without any conditions provided the computer was not used for any domestic work and

it would be re-exported within a two year period. The DoE tried to push as many importers as possible to the last category. In any case, all importers had to sign a legal bond with the CCI&E and those failing to meet their obligations could have their machines confiscated and be subject to legal action.

The 1984 Policy Shift and the Transformation of the DoE

Although the DoE had given 86 approvals for computer manufacture by 1 December 1981 under the Microcomputer Policy of 1978, only six licensees went into production.[21] The local content in manufacturing was low among the licensees, reflecting the limited financial resources and design skills at their disposal. Concerned with the state of affairs, he EC took upon itself the task of revising computer policy in the latter half of 1982. After much input and debate, a draft policy was approved on 14 September 1983. But the draft never became policy. Instead, a different version of the new computer policy was announced on 19 November 1984, within twenty days of Rajiv Gandhi taking office as PM. In contrast to the EC approved draft which, despite giving a significant role for the private sector, "asserted that the guiding principles were to be national control over the production base and major application areas of computers,"[22] the new policy effectively abandoned that premise. In a significant departure, it aimed at developing manufacturing capabilities in the country incorporating advanced technologies, simplifying procedures and promoting applications for development.

The manufacture of mini and microcomputers was now open to any Indian manufacturer, except those with more than 40 percent foreign equity, and all restrictions on production capacity were removed. Import procedures were also simplified. Although the policy did not look too critically at manufacturing operations that were little more than the assembly of imported CKD/SKD kits, it established minimum viable capacities and required manufacturers to follow a phased manufacturing program to indigenize the industry.[23] Despite the simplification of import procedures, domestic manufacturers were to be protected initially with high tariffs, although there was to be a progressive reduction in tariffs to force them to compete at international levels. As a start, the policy allowed educational, research and defense institutions to import without any duties. Other users could import computers not available indigenously for a low duty provided the computers were among those approved by DoE. Though it never happened, the idea of approving 12 to 18 models was an attempt to standardize machines in the country so that the DoE could negotiate bulk purchases and ensure the availability of software. As for the manufacture of mainframes, they continued to be reserved for the public sector, i.e. ECIL, though the reservation was to cease after two years.

The policy also made changes that affected software directly. The DoE was to establish a Software Development Promotion Agency to promote development efforts both for the local and export markets, and also set up a research, design and development facility. Software was recognized as an "industry," making it eligible for investment allowance and other incentives, and it was freed from the demands of locational policy. Duties for the import of software were lowered—source code and object code could be imported at 60 percent *ad valorem*, instead of 100 percent, while source code as printed matter attracted no duty at all. The import of application software was more cumbersome and continued to attract a high rate of duty.

Though the 1981 policy continued to provide the basic framework for exports, software export over satellite data links was now permitted. The National Computer Network INDONET was also to be made available for software exports. The import of computers for software export was permitted at a special low duty and exporters were permitted to retain 50 percent of their foreign earnings beyond their obligation in any year for any purpose. Income from the provision of services at customers' sites overseas, including bodyshopping, was also to count as exports. Bodyshopping refers to the practice of software firms offering programming services, typically for low-value added services, where billing is directly proportional to the number of programmer-hours contracted.

The prime mover behind the new policy was N.Seshagiri, Additional Secretary at the DoE and Director General, National Informatics Center (NIC). Although Seshagiri was part of the atomic energy network that had entered the DoE when it was first formed, by the early 1980s, he no longer subscribed to autarkic views. Seshagiri had argued in various fora that existing policies and procedures were too restrictive and cumbersome. He wanted to quickly build a strong domestic industry without being wedded to self-reliance. He also argued that if India were to realize its software ambitions, of becoming to software in the nineties what Taiwan and South Korea were to hardware,[24] it would have to begin with high volume, low-value-added exports and then move up the value chain.[25] To him, it was the failure to follow such a strategy that had left India far behind East Asia in hardware exports. Thus, the policy explicitly recognized all on site services as valid exports.

Seshagiri's ideas had to wait until they had the right backing. In May 1984, ECIL chairman Vijayakar moved to the DoE take over as Secretary. His first hand experience with the problems that ECIL faced with the TDC 332 made him take a pragmatic approach to the question of foreign technology and self-reliance. Unlike Menon or Nag, who were academics, Vijayakar was an engineer with a commercial outlook. A few other senior

bureaucrats, including the then Cabinet Secretary and the Industries Secretary, were also supportive of Seshagiri.

Politically, crucial support came from Shivraj Patil, Minister of State for Science and Technology, and from Dr.M.S.Sanjeevi Rao, the Deputy Minister of Electronics and the Chairman, EC, since November 1982.[26] Most importantly, Seshagiri had impressed Rajiv Gandhi when the two had interacted during the design and operation of the information systems for the 1982 Asian Games held in New Delhi. As his views fit well with Rajiv Gandhi's own interest in encouraging the widespread application of computers, Seshagiri came to be one of Gandhi's "computer boys," as the PM's team of advisers was popularly referred to. With the backing at the highest political level, he was able to push through the new policy without even formally informing the EC until February 1985. Seshagiri also became the chairman of the Inter-Ministerial Standing Committee (IMSC) in the DoE which, as per the new policy, was to be the last word on all matters pertaining to the regulation of the computer industry.

The 1984 policy succeeded in achieving one of its major objectives, which was to ease availability of computers, especially microcomputers. The production of micros grew almost ten-fold from 3400 in 1984-85 to 33,000 in two years.[27] Though international prices were two to three times lower than domestic prices, end-user prices fell by almost 30 percent in less than a year.[28] While there were a few who were concerned with the official sanction given to "screwdriver" technology, especially companies that had invested in developing local engineering skills, by and large, the hardware industry had much to cheer about.

In contrast, policy confusion and bureaucratic hurdles continued to afflict the software industry. On one hand, policy confusion arose in part because of a limited understanding of the industry. The confusion, however, had its advantages. Seshagiri would have been unable to push through his policy had it not been for misconceptions that prevailed about software among various policy makers:

> If the administrators and some of the bureaucrats had too deep a knowledge, they might have prevented bodyshopping or on site services. Software was seen as a glamorous hi-tech industry, so they said, all right, do it.[29]

At the same time, the basic framework remained unchanged. The issue of copyrights continued to plague the industry and, despite the industry being permitted to export with satellite data links, establishing an earth station was a long-winded procedure requiring permission from various government departments. Indeed, it required ingeniously removing or breaking 25 government rules before Texas Instruments (TI) could set up the first earth station in Bangalore.[30] For instance, no one other than the DoT was legally allowed to own, install and operate the earth station and

related equipment. To get around this, an arrangement was worked out whereby it was made to seem that TI, which had paid for the equipment, was merely renting the equipment from the DoT. TI's capital costs were adjusted against the DoT's "rental" charges.[31]

In response to industry concerns and demands, the government announced the Computer Software Export, Development and Training Policy on 18 December 1986. The aim of the policy was to increase India's share of world software production by facilitating a "quantum jump" in India's software exports besides promoting the domestic industry. The key feature of the policy was "flood in, flood out": Indian firms would be provided liberal access to the latest software and software tools so that they could enhance their international competitiveness, and exports could have a higher value-added content. To that end the policy placed software imports in the open general license (OGL) category i.e. software could be imported in any form in any quantity by anybody by paying 60 percent *ad valorem* duty.[32]

Various other procedures were also simplified. Those wanting to import hardware for software export now had to apply to the IMSC that would convey its decision in six weeks. The IMSC clearance would also automatically ensure an import license from the Joint Chief Controller of Imports and Exports and foreign exchange from the Reserve Bank of India. The importer would merely have to deal with the Computer, Communications and Instrumentation (CCI) wing of the DoE, which would employ the necessary "chasers" to obtain all post-IMSC clearances. Applying through the IMSC was no longer the only alternative either. Applicants could also go through the Export-Import (EXIM) Bank. Not only was this approach faster but imports through this route were also given a 50 percent duty rebate.

Importers who went through the IMSC and needed foreign exchange from the government had to generate net exports equivalent to 250 percent of the amount. For those using their own foreign exchange the obligation was 150 percent, while using the EXIM Bank route came with a 350 percent obligation. Whatever the obligation, it had to be earned within four years with specific annual targets.[33] Those failing to meet these obligations had to pay a penalty equal to the export shortfall. Exporters could, however, retain up to 30 percent of excess export earnings and use it to make new investments to generate further exports. Firms were also given a foreign exchange allocation of up to 30 percent of their previous year's earning for overseas travel and other marketing expenses. To ease the availability of funds at home, the policy promised to make venture capital available.

Ultimately, Seshagiri hoped that providing easy access to technological developments overseas and encouraging foreign investment would have a

domino effect, "encouraging thousands of small software companies in the country and thereby increasing export as well as local development."[34] He also wanted industry to be independent, with the government only stepping in to provide promotional and general infrastructure support. Overall, this policy was radical, as it explicitly rejected Indian ISI and the ideology of self-reliance, even as broader economic policy in the 1980s was characterized by tentative liberalization with efforts to simplify the regulatory and administrative regime without making major policy departures.[35]

While the new policy was welcomed by the large, export oriented firms, smaller firms had their grouses. First, a net export obligation of 250 percent meant that gross exports would have to be at least 500 percent of the value of imported hardware and software. This, along with the annual targets, was felt to be too stiff for new firms entering the export market. Other biases against small firms followed. In 1987, the Software Development Authority, which was established by the DoE in 1986 to formulate and coordinate software policy, announced that software firms had to register with the DoE to receive export promotion assistance. Initially, only firms with exports of Rs.5 million in the previous year were eligible, though that figure was reduced to Rs.1 million (US$ 72,000) in 1988 and to Rs.0.2 million (US$ 12,500) in 1989. Similarly, in 1988, firms exporting more than Rs.100 million ($7.2 million) were permitted to pay off their export obligations in any manner whereas smaller firms were restricted to exports using the imported computer. But an earlier decision to disallow the import of either used computers, or computers on loan, was reversed. Such computers could now be brought in at 20 percent duty for up to a year with a 50 percent export obligation and up to 6 months with a 25 percent obligation.

Second, firms focusing on the domestic market felt that placing software under OGL would kill local efforts. In response to this concern, new norms were announced in February 1987 for the import of software under OGL. It was now to be restricted to actual users, including government departments and computer manufacturers, the DoE, and firms registered with the DoE as distributors of foreign software, or "stock and sale" as it was referred to. In April, the government tightened the norms further: "stock and sale" was only permitted either with the 30 percent excess export earnings or up to 50 percent of income tax paid on the software activities of the firm in the previous year. The duty on imported software was raised from 60 to 65 percent in 1988 and to 107 percent in June 1989. But these steps ensured that only the largest firms could continue to import, without necessarily addressing the question of how imports were affecting local efforts.

As duties went up the government also levied a 15 percent travel tax that hit software firms hard as most of them relied on supplying on site services to their clients. The raising and imposition of duties did not affect the software industry alone; they also affected the hardware industry. In the 1987-88 budget, a 10 percent excise tax was re-imposed on computers. The following year's budget laid a uniform duty of 98 percent on all imported systems and peripherals to replace duties that varied between 0 percent and 147.5 percent. The 1988-91 export-import policy shifted many peripherals and computer sub-assemblies from OGL to the "limited permissible list," which required prior clearance. An export obligation of 30 percent of ex-factory value in the case of computers, and 15 percent in the case of peripherals, was imposed on all computer firms approved after April 1986 that needed to import components.

The tightening of trade and import policies reflected India's growing inability to pay for imports following the policy liberalization, and Rajiv Gandhi's efforts to shore up his political fortunes after his liberal policies began to be perceived as elitist.[36] There were changes at the DoE too. Seshagiri was transferred from the DoE as full time head of NIC in January 1988 following a power struggle between the IMSC and K.P.P.Nambiar who had taken over as Secretary, DoE, in January 1987. But despite the backtracking with trade and import policies, some promotional policies did continue. In 1987, an insurance scheme was introduced protecting clients from Indian software companies and, in 1988, one-year visas were offered for overseas trainers.

In 1988, the Commerce Ministry sponsored the Electronics and Software Export Promotion Council (ESC) to promote electronics and software exports. Although the Engineering Export Promotion Council (EEPC) had constituted a software panel in 1981 and included industry representatives on trade visits abroad, ESC was formed because it was felt that the EEPC was responsible for too many sectors to be able to pay any special attention to software exports.[37] The ESC grew from 40 members to 1800 members in the mid-1990s, 600 of whom were software firms. It has a working committee to which 25 members are elected once every 2 years. The committee includes four members from the government at the Joint Secretary level, two of whom are from the Commerce Ministry and one each from the DoE and the Finance Ministry. ESC's focus is to discover markets, to provide contacts, and to remove domestic hindrances to exports. To that end it regularly takes up space at trade exhibitions overseas and lets it out at subsidized rates to firms. Although such marketing measures are not directed at helping individual firms as such, they are "praised by both companies and independent commentators as helping larger companies to diversify their collaborations and helping small companies to find clients."[38]

In 1988, the industry also formed its own trade body, the National Association of Software and Service Companies (NASSCOM), to promote its interests. When it was formed, NASSCOM had 38 members who accounted for 65 percent of the industry's revenues. A decade later, it had 464 members, accounting for 95 percent of industry revenues.[39]

Software Technology Parks and Other Policy Initiatives since 1990

While the policies of 1984 and 1986 signaled a liberal shift in India's computer policies, the shift in the political fortunes of Rajiv Gandhi slowed promotional policies after 1987. According to Pronab Sen, former economic advisor at the DoE, amidst the euphoria following the growth in software exports in the 1980s, arrogance and ignorance also encouraged the opinion that the software sector did not need much by way of policy support.[40] Thus, he scathingly writes, "Until 1991-92, there was virtually no policy support at all for the software sector. Even the term 'benign neglect' would be too positive a phrase to use in this connection."[41]

There was ambivalence within the government about actively promoting bodyshopping as some of the more technologically conversant policy makers were critical of "intellectual coolieism."[42] More crucial to Sen was the failure to provide reliable telecommunication facilities, in the absence of which Indian firms had no option but to resort to on-site services.[43] He points out that the lack of data communication facilities also meant that India was unable to take advantage of the global demand for data-entry services, something that it could have well done given its work-force.

It was not until N.Vittal took over as Secretary DoE on 20 June 1990 that many of the specific concerns of the software industry were addressed. When Vittal took charge, the then Cabinet Secretary asked him to "do something" about software.[44] Vittal was a vociferous advocate of liberal policies and, though he had no prior awareness of the issues affecting the software industry, he was familiar with running an industry, in contrast to most other bureaucrats. His career as an officer of the Indian Administrative Services (IAS) included a five-year stint as Managing Director of the Gujarat Narmada Fertiliser Corporation (GNFC). While at GNFC he had set up a printed circuit board plant and a plant to manufacture TV glass shells. Vittal therefore set about rapidly to address the concerns of the software industry. The industry wanted high-speed data communications facilities for exports and lower import duties on software. It wanted service exports to be treated on par with merchandise exports. Specifically, it wanted profits on exports to be exempt from taxes and a concession on the import of computers under the Export Promotion Capital Goods scheme.

Based on his dialog with the industry, Vittal drew up a policy package and presented it before a meeting of the Committee of Secretaries on 30 August 1990. At this meeting, the Finance Ministry agreed to clear the whole package provided he could guarantee a five-fold increase in exports, to $500 million, in a year. Though they finally settled on a still unrealistic target of $400 million, Vittal decided to accept it arguing that somebody had to take a bold leap forward. Not only did industry fail to meet the target, many concessions also did not take immediate effect due to the prevailing political uncertainty. The concessions had to wait until the Narasimha Rao government took office in June 1991.

Although many aspects of his package could not take effect immediately, Vittal pushed to initiate the Software Technology Parks (STP) scheme to promote software exports from India using data communication facilities. The idea had been talked about since 1986, after TI unambiguously demonstrated the potential of offshore development: it was possible to encourage the growth of an industry that utilized high-skilled labor at home, instead of sending it overseas to work at client sites.[45] But, as mentioned earlier, TI had to cross many bureaucratic hurdles before establishing its satellite connection. Even after operations commenced, security concerns prompted the Intelligence Bureau to post a person at TI's offices to check samples of the data being sent.[46] It was in an effort to overcome such hurdles that the STP scheme was established.

Under the STP scheme, firms are allowed to import equipment without an import license or having to pay an import duty. Similarly, equipment purchased from the domestic market is exempt from excise duty. Foreign equity up to 100 percent is permitted and firms are allowed to freely repatriate capital investment, royalties and dividends after paying the necessary taxes. In return, there is an export obligation. Firms have to earn a net amount equal to 150 percent of the hardware imported within four years. They also have to earn a net amount equal to 150 percent of their wage bill on an annual basis. Although the STP scheme was meant for 100 percent export units, in January 1995 STP firms were allowed to sell up to 25 percent of the value of their exports to the domestic tariff area. The figure was revised to 50 percent in 1999.

Administratively, the STP scheme provides a decentralized, single window clearance mechanism for applications from investors. The Directors of the individual STPs handle the export valuation, letters waiving import licenses and customs duty, and other formalities. In 1993, the Directors were also granted the power to clear projects without foreign equity up to Rs.30 million, a figure that was later raised to Rs.100 million. The local Directors were given wide-ranging powers in the hope that each one would become a "friend, philosopher and guide" to the industry while also functioning as the eyes and ears of the DoE.[47] Inclusion of industry

representatives on the boards and councils of the STPs was also meant to emphasize the industry-friendly approach of the scheme.

In establishing the STP scheme, the DoE had to intrude on the turf of other ministries. Though the scheme is in principle no different from the 100 percent export oriented unit (EOU) scheme or the export processing zones (EPZs) established by the Commerce Ministry, the DoE had its own reasons for establishing separate facilities. First, it argued that the export potential of the software industry merited special attention. Since the EOU scheme and the EPZs cater to various industries, the people who administer them often have little knowledge of the software industry.[48] Many regulations governing the EOU and EPZ schemes were also not meaningful when applied to the software industry as the issue of disposal of obsolete hardware showed.[49] Under the EOU/EPZ schemes, inputs that are imported duty-free are bonded i.e. they cannot be removed from the premises. They can be de-bonded and sold in the domestic tariff area (DTA) only if all the duties that apply to imports to the DTA are paid. This presents a problem with hardware that becomes obsolete very rapidly and has little resale value after a couple of years. In the absence of clear regulations, the unwanted material would just lie around occupying space.[50]

Similarly, the DoE also felt that the export obligations for firms, based on value-added criteria, were unrealistically high in the EOU and EPZ schemes.[51] It wanted to place realistic shadow prices on the two scarce resources, foreign exchange and skilled labor, so that artificial constraints were not placed on exporters. The 150 percent export obligation on foreign exchange used over a four-year period, and the annual 150 percent obligation based on the wage bill, was set with an eye on competition from other low-wage countries such as China and the Philippines.

While STPs can be established by anybody, anywhere in the country, when the scheme was first formulated, reliable and affordable high-speed data communications facilities were not available. The 9.6 Kbps lines provided by the DoT and VSNL did not have enough bandwidth, while the three 64 Kbps lines were each priced at an equivalent of $180,000 per annum in comparison to the internationally prevailing rate of $84,000.[52] When asked to provide more 64 Kbps lines, the DoT wanted users to deposit money up front so that it could be certain that the demand existed for a service it would then provide 18 months later.

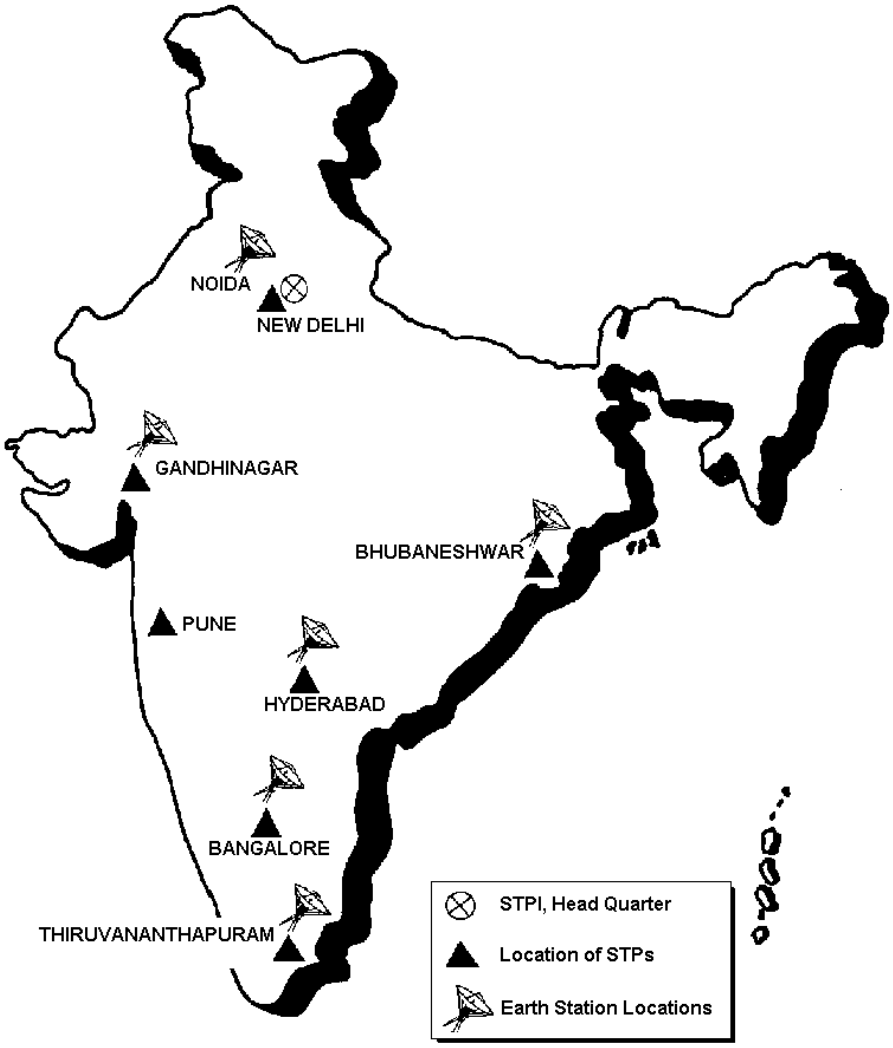

Figure 4. Geographical Distribution of the DoE's Software Technology Parks. *Source:* STPI.

To get the STP scheme going, the DoE intruded on the turf of the DoT and took the initiative to provide data communication facilities and other infrastructure by establishing its own STPs. The first STPs were established in Pune, Bangalore and Bhubaneshwar in September, October and December 1990 respectively (Figure 4). In June 1991, the Software Technology Parks of India (STPI) was registered as an autonomous society under the DoE and the three STPs established the previous year were brought under its umbrella. Later, in 1991, in addition to the STP at Noida, three more were established in Gandhinagar, Hyderabad, and Thiruvananthapuram at the initiative of their respective state governments. The first earth station was commissioned in Bangalore in April 1993, followed by Hyderabad in October 1993 and Thiruvananthapuram in April

1994. The DoE provided 90 of the 200 64Kbps links in the country in 1994.[53]

The DoE's STPs provide infrastructure such as core computer facilities, reliable power, ready to use office space and high-speed data communication facilities including 64 Kbps lines, internet access, remote log-in and video-conferencing. Office space and shared computer facilities in the STP are meant to encourage small firms, while larger firms that can afford their own space and hardware can locate anywhere within a 30 kilometer radius and connect to the earth stations with a microwave link. The STPs also have a mandate to undertake technology assessments and market analysis besides organizing training programs for software professionals and encouraging the acceptance of new ideas in software engineering.

Soon after the establishments of the first STPs, a balance of payments crisis in mid-1991 forced the Narasimha Rao government to turn to the IMF for a fiscal stablization plan.[54] This plan was accompanied by a structural adjustment program whose aim was to increase the efficiency and competitiveness of the economy by relying on foreign technology and FDI to a greater extent than was hitherto the case. To that end, a New Industrial Policy (NIP) was announced on 24 July 1991.[55] The NIP permitted FDI in virtually all sectors of the economy and substantially loosened licensing to ease entry barriers for new firms. India also demonstrated its seriousness in this pursuit by joining the Multilateral Investment Guarantee Agency in April 1992.[56] This was not just a one-way flow and soon international investments were also permitted. In 1997, software firms were allowed to invest in joint ventures and wholly owned subsidiaries abroad to the extent of 50 percent of their foreign exchange earnings in the previous three years, subject to a maximum of $25 million. In 1998, they were also allowed to offer ADR/GDR linked stock options to their employees.[57]

In July 1991, the Rupee was devalued by 24 percent and made convertible on the current account, which made Indian software cheaper globally.[58] Further encouraging software exports was the income tax exemption granted to profits on service exports under Sections 10A and B, and Section 80HHE of the Income Tax Act. Initially, this exemption was granted on an annual basis before being made permanent in 1995. On the trade front, the duty structure was rationalized and, in the case of software, they were reduced from 114 percent in 1991 to 0 percent by 1997.[59] Royalty payments were liberalized[60] and foreign trademarks and brands could be used freely in the domestic market. Thus, in April 1993, Indian companies were allowed to import software packages at the regular duty and then pay a taxable royalty on each copy duplicated and sold in the country. DoE permission was required only if the royalty was more than

30 percent of the local price. The Indian Copyright Act, 1957, was amended in 1994 to levy stiffer penalties on copyright infringement.[61]

While the many economy-wide policy changes of the 1990s undoubtedly helped the rapid growth of the software industry, many sector-specific policy changes and initiatives also emerged from NASSCOM's constant interaction with the government.[62] NASSCOM is represented on various committees of the GoI in the DoE, the DoT, the Ministries of Commerce, Finance, External Affairs, Human Resources Development and Labour. Apart from its interaction with the state, NASSCOM has tried to cultivate a public constituency for the industry. For instance, regular "club" meetings are held in major cities

> over cocktails where we invite the member companies, government officials, the press, leading IT users, politicians, bureaucrats, diplomats. It is a meeting ground where a lot of information is exchanged, people are able to talk frankly. It creates a good understanding between people across segments, not only among members. We hold meetings very often, about six club meetings per year per city.[63]

The result of such efforts was the creation of an awareness of the policies needed to promote the information technology (IT) industry, and their potential benefits, among the political leadership, the upper echelons of the bureaucracy and the urban intelligentsia. A leading business weekly describes NASSCOM as an "organisation that has lobbied for policy changes openly, transparently, and in a well-planned manner in India and abroad on a wide variety of subjects and achieved considerable success."[64]

NASSCOM also acts as a consulting body for various state governments. By the late 1990s, virtually every state had an IT policy, at least on paper, and promoted itself as the next Silicon Valley.[65] In addition to an IT policy, state governments typically try to attract the industry by providing infrastructure either on their own or by encouraging the private sector. In 1998, there were at least 25 STPs under various stages of planning and development in different parts of the country.[66] This was in addition to the STPs under the DoE. For instance, the Information Technology Park (ITPL) in Bangalore, is a partnership between the Government of Karnataka, Tata Industries and a consortium of Singapore firms. While the data communication links at these new parks are provided by the Videsh Sanchar Nigam, India's monopoly international telecommunications carrier until recently, private STPs, unlike the DoE STPs, are allowed to provide connections only to firms within their premises. To overcome such limitations, private parks began to provide other infrastructure such as residential units and recreational facilities.

The Indian Software Industry that Emerged

Having described the policy changes that played a crucial role in the emergence of an Indian software industry, the paper will briefly describe the characteristics of the industry that emerged. One key feature of the Indian industry was the ability to offer the specific expertise in demand by the global market for software services. The departure of IBM in 1978, and the failure of ECIL to develop a commercially viable computer, had forced most Indian users to rely on imports. But since high duties proved a disincentive to import, mainframes never had a significant presence in India. Even the few mainframes that were imported came from various sources. As a result, in 1990, Computer Maintenance Corporation (CMC), the PSE established in 1975 with ex-IBM staff to maintain and service all computers not manufactured locally, was supporting 923 computers of approximately 60 models of various vintages made by 34 manufacturers.[67] Thus, in the 1970s, Indian programmers worked on a variety of platforms. This proved helpful in the 1980s in acquiring contracts for the maintenance of various legacy systems.[68]

With the growth in computer manufacture and usage in India in the 1980s, Unix became the operating system of choice. As it undertook limited computerization of some of its activities the government also played an important role in encouraging the use of Unix. For instance, the Rangarajan committee's report on bank automation took the advice of CMC and recommended the adoption of Unix-based systems. This potentially large market encouraged investment in research and led to many innovations in the design of Unix-based hardware in the late 1980s and early 1990s.[69] Firms obtained the Unix source code and modified it to run on the machines they designed. The DoE helped fund and coordinate import substitution work in Unix.

The importance of familiarity with Unix cannot be overemphasized. Unix itself was first developed by Ken Thompson and Dennis Ritchie in 1969 at Bell Laboratories as a multi-user OS to provide a comfortable programming environment.[70] Even as the usage of Unix spread, AT&T refused to support it, forcing users to come together to share information and ideas. AT&T's liberal licensing of Unix to many universities across the world was particularly conducive to fostering a collaborative spirit and Unix developed as a truly open system.[71] It is widely used as the world's leading computer vendors adopted different various versions. According to a review on its 25th anniversary,

> Putative standards and consortia have done nothing to calm the splintered 25 year old. Solaris, HP-UX, AIX, Ultrix, and myriad derivatives sit at the . . . table today. Since the late 1970s, Unix has influenced every operating system that is sold today. Unix has had a profound impact on DOS, Mac OS, and Windows

> NT. Windowing, multitasking, and networking would not be what they are today without Unix.[72]

As circumstances forced Indian programmers and engineers to adopt Unix,

> India entered the 1990s in a position of special advantage. Indian programmers are not only well educated and English-speaking, but out of necessity they're keenly focused on client/server or multi-user solutions for PCs running DOS (with Netware) or Unix—just the kinds of solutions that U.S. and European companies are rushing to embrace.[73]

Despite the expertise, exports grew slowly in the 1980s, because Indian software firms were stuck in the relatively low-value added production segments such as coding and testing, or in maintenance and reengineering[74] tasks, as opposed to the more conceptually demanding and lucrative segments such as requirements analysis or design.[75] Further, a substantial proportion of the low value-added software exports took the organizational form of on-site services which, in the case of Indian firms, meant bodyshopping. Bodyshopping had its advantages and limitations. On one hand it provided easy access to the global market as it represented

> almost 'inputless exports,' which require only a contact overseas, a little finance, and the names of local programmers who can be hired if a contract is forthcoming. Such a path can also be followed relatively independent of government policy measures, particularly those on imports, because no imports are needed.[76]

The drawback, however, was that once sent overseas, many employees tended to quit and seek better paying and professionally more challenging jobs. The high employee turnover only reinforced the tendency of Indian firms to compete on the basis of low costs rather than being able to fall back on a repository of technical and managerial expertise acquired from previous projects. It also led to an under-utilization of Indian engineering talent.

Despite the drawbacks of bodyshopping, and the kind of work that it entailed, firms had few other options. In the absence of easily available and affordable data communication facilities, firms could not shift to offshore services. Further, with the exception of a few firms such as Tata Consultancy Services (TCS), which has been an exporter since the 1970s, it was not until the 1980s that Indian firms began to make their presence felt as suppliers of software in the global market. Firms from a country that had hitherto merited no consideration as a source of IT products had to establish their credibility with global customers before the latter could be convinced that their software, that was strategically crucial to business operations, could be written several thousand miles away. A study of 230 projects across 125 firms in India shows that reputation matters in software contracting, even after controlling for project, firm and client

characteristics.[77] A reputation could not be established overnight and had to wait until at least a few projects were completed satisfactorily. Interviews with industry representatives indicated a widespread agreement that, in order to gain the confidence of western customers, there was no alternative to on-site services in the 1980s. Besides, while Indian engineers had the necessary technical skills, they had been trained in a closed economy. On-site services provided exposure to not just new technologies but also management processes, market trends and socially specific communication protocols with customers.

During the 1990s, however, the Indian software industry underwent significant changes. There was a shift away from onsite to offshore facilities following the commissioning of the STPs (Figure 2). It is more than mere coincidence that the shift from a linear to an exponential trend in software exports began in 1993, the year that the first earth stations were commissioned at the Bangalore and Hyderabad STPs. STPs have also proven popular with industry as the rising share of STPs in software exports illustrates (Figure 1).

STPs became popular because, as one interviewee mentioned, they provided a "step-function jump" in terms of the work done and value-added at home. For instance, firms could exploit the 12.5-hour difference between Indian Standard Time and Pacific Standard Time to undertake maintenance and reengineering after regular users in the US left for the day. This, in turn, meant lower costs and greater profitability, as overall resource costs in India are only about a third of what they are in the U.S. One reason for the lower costs is that engineers in India can be paid just an Indian wage whereas, once abroad, they also have to paid an overseas allowance to cover their expenses.[78] Offshore development also offered the advantage of having most employees under one roof instead of them being scattered across many customer sites. This allows them to interact with one another and learn from other projects in a way that communication by email alone does not permit. It also helped firms build a repository of knowledge that helps in competing for subsequent projects. Though this did not overcome the problem of employee mobility and labor turnover, in the event of a crunch, employees could be moved from one project to another or new hands could be hired at local wages.

With the availability of data communications facilities, offshore software factories emerged complete with the infrastructure, technology, training programs, quality processes, productivity tools and methodologies of the customer workplace. For instance, by October 1999, 140 Indian firms had obtained the ISO 9000 certification offered by the International Standards Organization, and 134 firms were awaiting certification.[79] 27 firms had obtained SEI-CMM certification of the Software Engineering Institute's (SEI) five-stage Capability Maturity Model (CMM).[80] Not only were six

of the world's 12 CMM Level 5 firms Indian, but NASSCOM also claimed that in the software industry, India would "soon have more ISO 9000-certified companies in the world than any other country."[81] There are at least two reasons why quality certification is widely sought by the Indian software industry.[82] First, it is a marketing device, to signal to potential customers that the certified firm follows a well-defined and documented development process. Second, a well-defined process improved the ability of firms to estimate and manage the time and resources required for a project, helping them bid for larger projects, thereby expanding business.

Although the relationship between certification and better rates is not very robust, for firms with an on-going commitment to quality, getting bigger projects is a route to obtaining more profitable contracts.[83] Interviews indicated that firms with a proven record were able to bid for projects directly with clients rather than work as subcontractors for other vendors. This opened the doors to turnkey contracts, giving Indian firms responsibility of coordinating a much wider range of tasks than just programming. They had to take responsibility for the overall project schedule, quality and productivity, in contrast to bodyshopping which is little more than resume selling.

For firms that developed the managerial skills and proved their ability to deliver, there were significant benefits. According to a representative of a MNC software firm, who was otherwise highly critical of the Indian industry,

> a few large companies have established themselves to the extent where they are granted large consultancy or development contracts. Companies like TCS, CMC, Infosys have established a reputation out there. They are past that hurdle of a dollar a day kind of savings. In fact, there are instances of these companies charging essentially international rates and getting away with it because the work needed certain talent that they had.[84]

Not only were some Indian firms getting better work at better rates, but they also began to move away from competing solely on the basis of hour-based productivity to intellectual property rights based productivity. They did so by converting critical knowledge gained during consulting projects, in specific application areas, to a generic product that is subsequently customized for clients with similar needs.

Even as Indian firms were establishing their credibility, many Indians who had migrated to the US were distinguishing themselves professionally. Since the passage of the Immigration Act of 1965 removed restrictions on Asian migrants, by allowing immigration based on of either the possession of scarce skills or family ties to citizens and permanent residents, Indians went to the US for higher education and employment. Although Indians

have accounted for less than 5 percent of all migrants, they have also accounted for nearly a fifth of all migrants with professional and special technical skills (Figure 5). The latter figure is more than double the norm for migrants from all other countries. By the 1980s, many Indians had entrenched themselves in positions of authority in various corporations and, by the 1990s, many were also taking the plunge as entrepreneurs.[85] On the basis of their own performance and the rising credibility of Indian firms, they could recommend India to their management, either as a possible software source or even as a production base in light of the policy changes taking place in India. A number of firms acknowledged the important roles played by Indians in the parent company in influencing, either explicitly or implicitly, the decision to work in India. One representative of a TNC described the Silicon Valley headquarters of his firm thus:

> If you walk . . . the halls, you will see an enormous number of Indians doing everything from development to support to design to marketing . . . VPs, senior VPs are Indians, a huge percentage of them. So there was no reason to prove that the skills existed.[86]

YEAR	% OF ALL MIGRANTS	PROFESSIONAL/TECHNICAL SKILLS	
		ALL MIGRANTS	INDIANS
1971-1980	3.65		19.50
1981-1990	3.42		13.40
1992	3.52	7.57	20.98
1994	4.12	8.36	18.70
1996	4.68	8.22	17.94

Figure 5. Migration from India to the United States, 1971-1996 (as a percentage of all migrants and as a percentage of migrants with professional and special technical skills). *Sources:* Immigration and Naturalization Service, *Statistical Yearbook of the Immigration and Naturalization Service*, (Washington, DC: GPO, various years); Rafael G. Alarcon, "The Migrants of the Information Age: Foreign-Born Workers and Scientists and Regional Development in Silicon Valley," Ph.D. diss., University of California, Berkeley, 1998, p. 83.

TNCs freely acknowledge that low wages were a big attraction in establishing ODCs in India, because the total cost of employing an engineer is only about 35-40 percent of what it is in the US. But most were at pains to emphasize that the real attraction was the availability of high quality skills. The *only* reason low wages matter is because they provide an attractive trade-off to working in an environment plagued by chronic uncertainties of infrastructure:

> We came here because of the skills. We expanded because of the skills. We were able to come to India because the risk of being 10,000 miles away, the risk of the satellite link and the telephones and the flights and the *Bharath bundhs*[87] were offset by the costs. But I cannot offset the skills by the costs.[88]

When TNCs started trickling into India from the mid-1980s for the skills, they did not trust that labor with tasks that similarly skilled labor undertook in the home country. Some even started off doing internal bodyshopping, i.e. recruiting engineers in India and sending them off to do projects overseas with the parent company before starting their ODC. When the Indian subsidiary of a German TNC set up a software export division in 1989,

> There were about 50-60 engineers working on various projects . . . across Europe . . . at a very competitive price without sacrificing quality. That was the origin. It went off very successfully and there were so many people working on projects there. Then the idea expanded and they said 'why should we go there . . . when projects can be brought back to India.' . . . Slowly an Indian base started with people who were coming back.[89]

Though TI did not resort to any internal bodyshopping when it set up the first ODC in the mid-1980s, a representative explained the evolution of the status of the Bangalore center within the global framework of TI, by detailing how the development of CASE (computer-aided software engineering) tools took place in Bangalore:

> Initially when the project started, we were doing reengineering work in the sense that TI was working closely with customers . . . who had their applications written in a COBOL-like environment and they wanted to migrate to this environment. So we started with application support kind of work where we used to visit all parts of the world, work with customers, understand their current environment and manually reengineer that application in this new environment. . . . But TI is consciously getting out of that business. . . . Though we still do some of that work, now the major thrust in India . . . is really on the product itself and not the final application. . . . The fact that the India organization has moved away from support means we are not playing just a wage game. When we do a project in India we ask ourselves the question, 'would I do this project if it was the US?' Earlier, in '85-'86, we wouldn't be asking such questions. But now these questions are definitely asked. In other words, India is an integrated member of the whole team and it is really one to one.[90]

Many TNCs chose to put software engineers in India on a learning curve especially when a specific domain expertise was not readily available. Until such expertise was acquired, TNCs took advantage of the availability of programming skills before giving programmers the kind of responsibility that engineers in the home country were given.

By the 1990s with the establishment of the STPs and after the early entrants of the 1980s had demonstrated that India could be much more than a low-wage hunting ground, there was a substantial increase in the ODCs of TNCs. Many shed their subordinate status and were undertaking projects either jointly or independently, as equal partners, with their parent organizations. Some even outdid their parent organizations. For instance, in 1994, Motorola's Bangalore center was only one of two software

centers worldwide (the other being Loral's space shuttle software project in the US) to attain CMM Level Five.[91] The local chief executive of a software firm, explained why they waited until the 1990s to establish the Bangalore ODC:

> Now . . . the feeling is that high-tech, leading edge quality, timely, delivered, supported software will come out. That was not a risk you could have taken five years ago. Five years ago, . . . they would have said no. If they had asked me, I would have said no. I would have said, 'do anything, bodyshopping, subcontracting, modular work, but don't give full dependability here because nobody's ever done it. It's not proven.'[92]

This CEO went on to compare the work done at his center with the work at the company headquarters in Silicon Valley:

> New products come from here, new versions of old products come from here…. products on a particular hardware platform come from here as opposed to an application for a customer or something like that. It's the same thing that they do over there. Technologically, there's zero difference.[93]

Conclusion

The essay has examined the evolution of public policy and policy-making institutions that facilitated the emergence of the Indian software industry. Policy changes took place in three phases: the pre-1984 phase, with its restrictive regulatory regime; a second phase between 1984 and 1990, when the regulatory regime eased; and a third phase in the 1990s, when there was more pro-active promotion of the industry. The changing policy regime was due to the changing characteristics of policy-making institutions, especially the DoE, following changes in bureaucratic leadership. In the 1970s, under the leadership of a technological ambitious scientific establishment focused on self-reliance, there was neither an industry nor any significant exports. It was only after more technologically and commercially pragmatic bureaucrats, with their global ambitions, took charge at the DoE by the early 1980s that a significant policy departure was attempted. The pragmatism was accompanied by a greater willingness to work with the industry, especially the private sector. Thus, despite the liberal shift in policies since the 1980s, it was only after dialog with industry that the key initiative in the form of STPs was launched.

The shift in policy, however, would not have been possible but for the political backing it had. With Rajiv Gandhi taking office as Prime Minister in 1984, there was a shift away from the autarkic economic model and software was among the first economy sectors that benefited from the shift. Subsequently, by the 1990s, the economy-wide liberalization helped the sector further and a virtuous cycle of export growth and policy liberalization was established. The timing of the political and institutional changes coincided with the increasing globalization of the software

industry with the rapid growth in demand for software following the PC revolution of the 1970s. Demand was then sustained by the popularity of networking in the 1980s, the commercialization of the Internet in the 1990s and other maintenance opportunities such as the Y2K problem.

While the market opportunities provided to the Indian software industry by technological developments since the 1970s, and the political and institutional changes behind the liberal policies that allowed the industry to seize the opportunities, were historically specific and socially contingent, the Indian experience nevertheless offers at least a couple of lessons for other NICs entering the software industry. The Indian experience shows that it is possible to enter the global market and go through a process of learning with the one key advantage that NICs possess: low-wage labor, although in the case of software the labor must also be relatively high-skilled. India entered the global market by capitalizing on the demand for low-cost but high-quality programming skills. As Indian software professionals and firms demonstrated technical expertise and increasing project management capabilities, it not only led to rapid growth in exports, it also began to gradually alter the relationship between the Indian industry and global markets. An appreciation of Indian capabilities was not limited to the awarding of more lucrative turnkey contracts by global customers; many global software producers also increasingly saw beyond the obvious cost-advantage to the technological advantage of locating development centers in India. The Indian strategy and experience with software services is not very different from the strategy and experience of a Taiwan or a South Korea in manufacturing, although there is one difference. Whereas in the case of the East Asian NICs, it was *mass* manufacture that provided the means for their "late industrialization" efforts, in the Indian case, it has been the provision of *custom* software services.

The relative weakness with mass producing and exporting packaged software or software products leads to the second lesson from the Indian case. Critical to success in packaged software is the ability to embody intellectual content from various domains into code that is able to address the functional needs of users in a domain.[94] The most effective way to continuously acquire evolving intellectual content in any domain is to locate close to the largest and most critical users whose decision to adopt any particular software as standard typically influences other users and unleashes network externalities.[95] But the limited demand for software in India is evident not only from the growing proportion of software produced in the country that is exported (Figure 1), but also in the spending on IT as a share of GDP.[96] For instance, in 1999, India spent 0.53 percent of its GDP on IT in contrast with 3.09 percent in the OECD countries or 1.81 percent in the Asia Pacific.[97] India failed to pursue a "walking on two legs" strategy that pays as much attention to policies

encouraging domestic demand and consumption of software as they do to supply and production for export.[98] The rationale for the strategy is that the domestic market provides a good learning opportunity before venturing into the often more competitive global market. Considering that the global market for packaged software grew at 11.8 percent in comparison to 7.8 percent for software services between 1990 and 1997,[99] and that the packaged software business is more profitable than services due to the near-zero marginal cost of electronic duplication,[100] India's relative failure in nurturing a domestic market offers another lesson.

Balaji Parthasarathy, "Globalizing Information Technology: The Domestic Policy Context for India's Software Production and Exports," *Iterations: An Interdisciplinary Journal of Software History* 3 (May 3, 2004): 1-38.

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[1] In 1999-2000, 62 percent of India's software exports went to North America. National Association of Software and Service Companies (NASSCOM), *Indian IT Software and Services Directory 2001*. (New Delhi: NASSCOM, 2001).

[2] Jeffrey Henderson, *The Globalisation of High Technology Production: Society, Space and Semiconductors in the Restructuring of the Modern World*, (London: Routledge, 1989). Also see John A. Mathews and Dong-Sung Cho, *Tiger Technology: The Creation of a Semiconductor Industry in East Asia*, (Cambridge: Cambridge University Press, 2000)

[3] Pronab Sen, "Software Exports from India: A Systemic Analysis," *Electronics Information and Planning*, 22,2 (1994):55-63.

[4] Ibid., p.56.

[5] Unless otherwise mentioned, the changes in policy described in this section and the next are drawn from Richard Heeks, *India's Software Industry: State Policy, Liberalisation and Industrial Development*, (New Delhi: Sage Publications, 1996); Eswaran Sridharan, *The Political Economy of Industrial Promotion: Indian, Brazilian, and Korean Electronics in Comparative Perspective 1969-1994*, (London: Praeger, 1995) and C.R.Subramanian, *India and the Computer: A Study of Planned Development*, (New Delhi: Oxford University Press, 1992).

[6] Cited in Subramanian, op.cit., p.133.

[7] The EC was wound up in May 1989.

[8] Joseph M. Grieco, *Between Dependency and Autonomy: India's Experience with the International Computer Industry*, (Berkeley and Los Angeles: University of California Press, 1984).

[9] Only the outline of the policy regime is described here. For the economic rationale and the political arguments for the policy, see Baldev Raj Nayar, *India's Mixed Economy: The Role of Ideology and Interest in its Development*, (Bombay: Popular Prakashan, 1989) and Sukhamoy

Chakravarty, *Development Planning: The Indian Experience*, (New Delhi: Oxford University Press, 1987)

[10] Isher J. Ahluwalia, *Industrial Growth in India: Stagnation Since the Mid-Sixties*, (New Delhi: Oxford University Press, 1985).

[11] Subramanian, op.cit., p.193.

[12] Ibid., pp.30-31.

[13] The DoE had licensed ICL to manufacture its 1901A system and, in 1977, it's 2903 and 2904 systems. But these were not in direct competition with ECIL's offerings.

[14] The DoE established the Regional Computer Centers (RCCs) in the 1970s. Though conceived by the Bhaba committee, the first center opened only in 1977, in Calcutta, because funding proved to be a problem. The centers proved popular with the public sector but the idea that they would be used by the private sector for software export, never took off. As computers became more easily available, and PCs provided an alternative to mainframes, RCCs became less relevant. Subramanian, op.cit.

[15] The Cabinet approved the guidelines in December 1975.

[16] Exchange conversion rates are taken from http://fx.sauder.ubc.ca/etc/USDpages.pdf.

[17] Government of India (GoI), "Report of the Review Committee on Electronics (Sondhi Committee)," *Electronics Information and Planning*, 7,6&7(1979): Appendix 12.5.

[18] Subramanian, op.cit., p.32.

[19] GoI, op.cit.

[20] Grieco, op.cit., Table 1.

[21] Subramanian, op.cit., p.40.

[22] Ibid., p.50.

[23] Ibid.

[24] Salim Lakha, "Growth of Computer Software Industry in India," *Economic and Political Weekly*, 25,1(1990):49-56.

[25] Author's interview with N.Seshagiri, former Additional Secretary, DoE, New Delhi, 24 June 1996.

[26] Ibid.

[27] Subramanian, op.cit., p.75.

[28] *Dataquest*, "The New Software Policy: Dr.Seshagiri Clarifies," January (1987):82-95.

[29] Seshagiri interview, op.cit.

[30] Ibid.

[31] Author's interview with Pronab Sen, former Economic Advisor, DoE, New Delhi, 19 June 1996.

[32] Being placed on the OGL list meant that an item could be imported by merely paying the import duty without obtaining an import license.

[33] 20 percent of the earnings had to come at the end of the 2nd year, and 50 percent by the third.

[34] *Dataquest*, op.cit., p.87.

[35] Atul Kohli, *Democracy and Discontent: India's Growing Crisis of Governability*, (Cambridge: Cambridge University Press, 1991).
[36] Ibid.
[37] Details of ESC obtained during author's interview with R.K.Singh, ESC, New Delhi, 19 June 1996.
[38] Heeks, op.cit., p.296.
[39] http://www.nasscom.org
[40] Sen, op.cit.
[41] Ibid., p.55.
[42] Interview with N.Vittal, former Secretary, DoE, New Delhi, 25 June 1996.
[43] Sen, op.cit.
[44] Vittal interview, op.cit. Details of administrative bargaining and coordination that follow are from the same source.
[45] Author's interview with N.Gopalaswami, former Joint Secretary (Software Development), DoE, New Delhi, 21 June 1996.
[46] Vittal interview, op.cit.
[47] Author's interview with S.K.Agarwal, Director, STPI, New Delhi, 20 June 1996.
[48] Gopalaswami interview, op.cit.
[49] Singh interview, op.cit.
[50] To address this issue, and to encourage computer use, firms were allowed to donate computers and peripherals at 0 percent duty after 2 years, to government-recognized non-commercial institutions such as schools.
[51] Sen interview, op.cit.
[52] Sen, op.cit.
[53] Ibid., p.62.
[54] See Vijay Joshi and Ian Little, *India: Macroeconomics and Political-Economy, 1964-1991*, (Washington D.C. and New Delhi: The World Bank and Oxford University Press, 1994) for an extended discussion of the factors leading to the 1991 crisis.
[55] Details of the NIP are from Charles Oman (ed.), *Policy Reform in India*, (Paris: OECD, 1996).
[56] By joining the Multilateral Investment Guarantee Agency, India was committing itself to protecting foreign investment against risks such as war, civil disturbance and expropriation.
[57] ADR/GDR- American/Global Depository Receipts. The ADR is a certificate issued by a US bank that trades like a share on NASDAQ, allowing the US investor to invest in a foreign market without having to deal with risk of currency transactions. ADRs represent a certain number of domestic shares of the firm deposited with the bank. GDRs are similar to ADRs, except that they are traded on international stock exchanges such as London.

[58] The weakening of the Rupee was underway even earlier. Between 1985-86 and 1989-90, the Rupee depreciated by 45 percent in nominal terms and 30 percent in real terms. See Joshi and Little, op.cit. Between 1991 and 2000, the Rupee declined from Rs.22.74 to the US$ to Rs.44.94. However, the falling value of the Rupee is hardly the only reason for the growth in Indian software exports. Between 1987 and 1993, only 40 percent of the growth could be attributed to the falling Rupee. The rest was "real" growth. See Sen, op.cit.

[59] See Isher J. Ahluwalia, "India's Opening up to Trade and Investment," in Oman, op.cit. for details of changes to trade policies.

[60] Technology imports are automatically approved for royalty payments up to 5 percent of domestic sales and 8 percent of export sales. For lump sum payments, the limit for automatic approval is Rs.10 million.

[61] The 1994 amendment to the Copyright Act came into effect from 10 May 1995. It clarified the rights of a copyright holder, the position on rentals of software, the rights of the user to make backup copies and imposed punishment and fines for infringement of copyright of software. According to Section 14 of this Act, it is illegal to make or distribute copies of copyrighted software without proper or specific authorization. The only exception is provided by Section 52, which allows a backup copy purely as a temporary protection against loss, distribution or damage to the original copy. A civil and criminal action may be instituted for injunction, actual damages (including infringer's profits) or statutory damages per infringement. With these amendments, even the criminal penalties were substantially increased. Section 63 B, stipulates a minimum jail term of 7 days which can be extended up to 3 years. The Act further states the fine ranging from Rs. 50,000 to 200,000.

[62] Author's interview with the late Dewang Mehta, former Secretary, NASSCOM, New Delhi, 26 June 1996.

[63] Ibid.

[64] Shivanand Kanavi, "Power Lobbying," *Business India*, 19 February – 4 March, (2001):50-56.

[65] *Dataquest*, "The Year of Hope," 15 July, (1999). www.dqindia.com

[66] *Dataquest*, "Parkin' Tales," 15 September, (1998). www.dqindia.com. These included one each in Andhra Pradesh, Kerala, New Delhi, Punjab and Rajasthan, two each in Gujarat and West Bengal, five each in Maharashtra and Tamil Nadu and six in Karnataka.

[67] Elizabeth U. Harding, "India: After IBM's Exit, an Industry Arose," *Software Magazine,* 9,14(1989):48-54 and Subramanian, op.cit., p.210.

[68] Software maintenance work arises when organizations are forced to use computer systems dating back to the pre-PC era because the older (legacy) systems embody years of valuable business information and experience and cannot be easily discarded. Such organizations can spend over 70 percent of their systems development budgets on maintenance activities because they "….operate what can only be regarded as software museums:

collection of systems that incorporate or exemplify all the significant developments in computing…., including some of the blind alleys. The result is the systems equivalent to a medieval city, a hotchpotch of dissimilar buildings and winding lanes where only the locals can find their way around". Alex Mayall, "Spaghetti Systems," *Which Computer?* 14, (1991):40. The hotchpotch structure makes maintenance very labor intensive. In the 1990s, format problems with older software, especially those involving dates, acquired urgency. The year 2000 or Y2K problem, for instance, arose from a programming convention that used only two digits to represent a year. This was originally done to save expensive memory. Under this convention, 2000 was read as 00, with potentially ruinous implications for sectors such as finance and banking, whose functioning relies on date-based calculations. The problem afflicted older mainframe programs using COBOL code in particular, but other systems were not immune either. Joe Celko and Jackie Celko, "Double zero,"*Byte*, 22,7(1997):89-91. Fixing the problem was not so much a technological challenge as one of scale and management. Norton Greenfeld, "UNIX and the Year 2000,"*UNIX Review*, 15,2(1997):7-10.

It was a laborious process requiring a lot of planning, project management and testing, with no quick fixes or silver bullets Peter de Jager, "Year 2000: The Silver Bullet Solution," *Datamation*, 43,5(1997):33-34. While the Y2K problem was the most publicized, other format problems with older software also manifest themselves in the 1990s. Another date problem had to do with global positioning system (GPS) satellites. A network of twenty-four satellites kept track of dates from midnight 5 January 1980 for 1024 weeks. On midnight 21 August 1999, the week counter was reset to zero. This did not affect the satellites as much as applications, such as global fund transfers, which rely on GPS time signals. A different kind of format problem was posed by the shift to the Euro, replacing ten European currencies, from 1 January, 1999. The situation was complicated because the Euro was gradually eased into use. Its introduction varied by country, industry and commodity and existing currencies were considered legal until 2002. Capers Jones, "Bad Days for Software," *IEEE Spectrum*, 35,9(1998):47-52.

[69] Heeks, op.cit.

[70] Peter H. Salus, "Unix at 25," *Byte*, 19,10(1994):75-82.

[71] The work done at the University of California, Berkeley, deserves special mention. Among the key players there were Ken Thompson, who had moved to Berkeley in 1975 as a visiting professor, and a few graduate students, prominent among whom was Bill Joy. Starting in 1977, various Berkeley Unix versions were released. With funding from the U.S. Defense Advanced Research Projects Agency (DARPA), version 4.1a was test released in June 1982 incorporating TCP/IP (Transmission Control Protocol/Interconnection Protocol) which later became the Internet

networking standard. After version 4.1c was released in late 1982, Bill Joy left Berkeley for Sun Microsystems, where 4.1c became the Sun OS.
[72] Salus, op.cit., p.82.
[73] Jon Udell, "India's Software Edge," *Byte*, 18,10(1993):55-60, p.56.
[74] Technical reengineering is a means of reducing and simplifying maintenance by essentially replacing the older software with equivalent new software i.e. changing its form without altering its function. The result is easier and more efficient data access by shortening access paths, providing better query facilities and distributing data among several servers. Other benefits include better security, elimination of bugs lurking in the older software, and laying the ground for functional enhancement. Typically, reengineering involves migration from a mainframe to a newer operating environment such as Unix and is also likely to entail a language change. For example, C is upgraded to C++ or unstructured Cobol in upgraded to Object Cobol. H.M. Sneed, "Planning the Reengineering of Legacy Systems," *IEEE Software*, 12,1(1995):24-34.
[75] Robert Schware, "Software Industry Entry Strategies for Developing Countries: A "Walking on Two Legs" Proposition," *World Development*, 20,2(1992):143-164; Peter B. Evans, *Embedded Autonomy: States and Industrial Transformation*, (Princeton, NJ: Princeton University Press, 1995), and Heeks, op.cit.
[76] Heeks, op.cit., p.85.
[77] Abhijit V. Banerjee and Esther Duflo, "Reputation Effects and the Limits of Contracting: A Study of the Indian Software Industry," *Quarterly Journal of Economics*, 115,3(2000):989-1017.
[78] Heeks, op.cit.
[79] National Association of Software and Service Companies (NASSCOM), *Indian IT Software and Services Directory, 1999-2000,* (New Delhi: NASSCOM, 1999).
[80] The five-stage model was originally developed to assist the U.S. Department of Defense in software acquisition. The 5 stages are: (i) initial - process is ad-hoc or even chaotic with few codified practices; (ii) repeatable - basic project management procedures track cost, schedule and functionality that permits repetition of successes in projects with similar applications; (iii) defined - documented and standardized engineering and management processes in place that are followed by all software development and maintenance projects; (iv) managed - software process and product quality understood and controlled with detailed quantitative measures; (v) optimizing - continuous feedback based on quantitative feedback from process. Mark C. Paulk, "How ISO 9001 Compares with the CMM," *IEEE Software*, 12,1(1995):74-83.
[81] NASSCOM, 1999, op.cit.,p.17.
[82] Ashish Arora and Jai Asundi, "Quality Certification and the Economics of Contract Software Development: A Study of the Indian Software

Industry," Working Paper No.7260, (Cambridge, MA: National Bureau of Economic Research, 1999).
[83] Ibid.
[84] Author's interview with industry representative, Bangalore, 30 July 1996.
[85] See Annalee Saxenian (with Yasuyuki Motoyama and Xiaohong Quan), *Local and Global Networks of Immigrant Professionals in Silicon Valley,* (San Francisco: Public Policy Institute of California, 2002); Annalee Saxenian, *Silicon Valley's New Immigrant Entrepreneurs,* (San Francisco: Public Policy Institute of California, 1999) and
Rafael G. Alarcon, "The Migrants of the Information Age: Foreign Born Engineers and Scientists and Regional Development in Silicon Valley," Ph.D. Dissertation, 1998, University of California, Berkeley for a study of the impact of changes in U.S. immigration laws and the role that immigrant engineers play in the advanced technology sectors of Silicon Valley, arguably *the* most important center for the US IT industry. The studies also show the importance of immigrants for entrepreneurship in the Valley and how immigrant engineers use their social networks to promote investment and economic development in their home countries.
[86] Interview with industry representative, Bangalore, 30 July 1996.
[87] *Bharath* is another way of referring to India and *bundh* is a Hindi word meaning, "to shut". *Bharath bundhs,* then, are calls given to shut down business in the country, usually for a day, as a form of protest. Typically, political parties call *bundhs*. Though the response to a *bundh* call in any region depends on the political influence of the caller, *bundhs* are a regular feature in India, which make costly disruptions to regular life.
[88] Author's interview with industry representative, Bangalore, 30 July 1996.
[89] Interview with industry representative, Bangalore, 14 May 1996.
[90] Author's interview with TI representative, Bangalore, 30 July 1996.
[91] David Sims, "Motorola Self-Assesses at Level 5," *IEEE Software*, 11,2(1994):92.
[92] Author's interview with industry representative, Bangalore, 30 July 1996.
[93] Ibid.
[94] Edmund A. Egan, "The Spatial Dynamics of the U.S. Computer Software Industry," Ph.D. dissertation, 1997, University of California, Berkeley.
[95] When the value of a product to one user depends on how many other users there are, the product is said to exhibit network externalities. For more on this see Carl Shapiro and Hal Varian, *Information Rules: A Strategic Guide to the Network Economy,* (Boston: Harvard Business School Press, 1999).
[96] This was despite some large scale and widely acclaimed efforts such as the railway passenger reservation project. For details of the railway

reservation project and similar efforts, see Ashok Parthasarathi, "The Development of Technology in Electronics: Some Case Studies," *Electronics Information and Planning*, 19,10(1992):545-562.

[97] Data from International Data Corporation. Asia Pacific refers to the following countries: Australia, China, Hong Kong, India, Indonesia, Japan, Malaysia, New Zealand, Philippines, Singapore, South Korea, Taiwan and Thailand.

[98] Schware, op.cit.

[99] OECD, *Information Technology Outlook: ICTs, E-Commerce and the Information Society*, (Paris: OECD, 2000).

[100] Egan, op.cit.