Exploiting Information Technology for Development
A Case Study of India

Nagy Hanna
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Nagy Hanna

The World Bank
Washington, D.C.
Nagy Hanna is principal economist in the Public/Private Sector and Technology Development Division of the Asia Technical Department, South Asia Regional Office.

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FOREWORD

This paper presents the issues and options involved in formulating a national strategy for information technology development and diffusion in a developing country. Using India as a case study, this paper takes into account the emerging international experience in this new field and blends it with Indian economic conditions. It also benefits from extensive interactions with Indian business leaders, private sector associations, and policy makers.

This paper is neither a blueprint plan nor a formal or informal Bank proposal. Policy makers and business leaders, both in industrial and the newly industrializing countries, are facing complex choices in responding to the potential of information technology. The paper draws on emerging best practices. However, India will need to adapt such practices to its institutional and economic conditions as well as aspirations. Any detailed blueprint for a national information technology plan should emerge from extensive discussion and consultative mechanisms between the public and private sectors in India.

Detailed design of action plans need to be based on detailed studies of the demand of information technology and assessment of alternative programs and delivery mechanisms. The paper thus only describes a vision and an approach towards the formulation of a strategy. It outlines the strategic issues and options and possible elements of a national strategy that would need to be further developed through the collaborative efforts involving public and private sector leaders.

This paper is expected to be of wide interest also to other countries as they address this emerging and challenging area of development.

Harold W. Messenger
Director
Asia Technical Department
ABSTRACT

This paper proposes a framework for developing a national strategy for information technology development and diffusion in support of economy-wide competitiveness. The specific country case is India, a developing economy with substantial promise to become a global player in the software services. It is also a country where timely information is scarce and transactions costs are high, and thus provides a developmental context for demonstrating the strategic impact of this technology. The study first analyzes the information and communication needs of India’s economy and the constraints to a dynamic domestic market for information and software services. The study then assesses the competitiveness of India’s hardware and software industries. Translating the potential of information technology into effective demand and successful application requires concerted action by the public and private sectors on developing policies, institutions, investments and capabilities.

The study outlines the rationale for a coherent and long-term strategy for information technology specifically tailored to enhance India’s competitiveness and exports. The main elements are: (a) measures to mobilize demand in the private sector and to target strategic applications for public sector modernization; (b) programs to strengthen software industry capabilities and export networks; and (c) policy and infrastructural measures to strengthen both supply and demand and lay the foundation for sustained development. Various options are proposed in support of each element of the strategy. The respective roles of government and private sector are explored. The argument is put forward that national information technology strategies could provide a coherent framework to exploit synergies and develop collaborative actions, and that governments can play key roles as catalysts, regulators, investors, users and strategists.
ACKNOWLEDGEMENT

This study is the product of many interactions and the synthesis of many ideas that I gained from working with Indian policy-makers, businessmen, academics, and consultants, as well as World Bank colleagues. In particular, Robert Schware contributed to the chapter on Supply, and Joseph Bredie to the Informatics Labor Force issues.

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I also benefitted from the peer review and support of many World Bank colleagues: Daniel Ritchie, Khalid Siraj, Gobind Nankani, Sidney Thomas, Javed Khalilzadeh-Shirazi, Carl Dahlman, Ashoka Mody, Arvind Gupta, Jeremy Openheimer, Geoffrey Gowen and Shakuntala Gunaratne. Sandor Boyson of the University of Maryland provided an independent and global perspective. Bruce Ross-Larson provided selective editorial assistance. Alloysius Ocheni provided valuable secretarial support.
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<th>Description</th>
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<tr>
<td>CAD</td>
<td>Computer Aided Design</td>
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<td>CAM</td>
<td>Computer Aided Manufacturing</td>
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<tr>
<td>CASE</td>
<td>Computer-Aided Software Engineering</td>
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<td>CII</td>
<td>Confederation of Indian Industries</td>
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<td>CMC</td>
<td>Computer Maintenance Corporation</td>
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<td>CRISP</td>
<td>Computerized Rural Information System</td>
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<td>DOE</td>
<td>Department of Electronics</td>
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<td>DOT</td>
<td>Department of Telecommunications</td>
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<td>EC</td>
<td>European Community</td>
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<td>EDB</td>
<td>Economic Development Board</td>
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<td>GNP</td>
<td>Gross National Product</td>
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<td>GOI</td>
<td>Government of India</td>
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<td>IISC</td>
<td>Indian Institute of Science</td>
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<td>IT</td>
<td>Information Technology</td>
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<td>MAIT</td>
<td>Manufacturers' Association of Information Technology</td>
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<td>NASSCOM</td>
<td>National Association of Software and Service Companies</td>
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<td>NCST</td>
<td>National Center for Software Technology</td>
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<tr>
<td>NIC</td>
<td>National Informatics Center</td>
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<td>NIE</td>
<td>New Industrializing Economy</td>
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<td>NPC</td>
<td>National Productivity Council</td>
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<tr>
<td>OECD</td>
<td>Organization for Economic Cooperation &amp; Development</td>
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<td>R&amp;D</td>
<td>Research and Development</td>
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<tr>
<td>RBI</td>
<td>Reserve Bank of India</td>
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<td>TCS</td>
<td>Tata Consultancy Services</td>
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<tr>
<td>TUL</td>
<td>Tata Unisys Limited</td>
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<tr>
<td>VSNL</td>
<td>Overseas Communication Corporation Limited</td>
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EXECUTIVE SUMMARY

The abundance of cheap labor and raw materials is no longer sufficient for global competition. Information, flexibility, product quality and fast response are the key new factors, and Information Technology (IT) plays a critical role in these areas. That is why policy-makers in industrialized countries—and in an increasing number of developing countries—view information technology as a critical infrastructure for competing in an information-intensive global economy. They also see the potential gains from using IT-based processes to enhance their access to global knowledge, markets, and capital. And they view IT as a fast-growing strategic industry that is likely to be the world’s largest before the end of the 1990s. These views—of information technology as infrastructure and as core capability for development—resonate with India’s aspirations to modernize its infrastructure, transform its industry, and join the global economy.

In a word: IT is transforming the way people do things—all things. Computing and communications technologies have—by increasing the amount and timeliness of information available to economic agents—dramatically increased the information intensity of processes, occupations, and institutions, as well as that of products and economies. In industrial countries, IT is enhancing the workings of markets and reducing transaction and coordination costs within and across enterprises and institutions. It is also modernizing such traditional "low tech" industries as textile and footwear, and revitalizing and transforming such basic industries as automotive and capital goods. Throughout industry, it is profoundly transforming competitive strategies, product development, manufacturing processes, and procurement practices. Similar transformations are occurring in all services: finance, trade, distribution, marketing, education, and health. These changes are inducing managerial and organizational innovations and new business practices—such as outsourcing, de-layering, time-based competition, lean production, just-in-time procurement, and flexible manufacturing. Now pervasive in OECD markets, these practices influence how—and how much—developing countries will participate in global trade in manufacturing and services.

India presents a major case study of the importance of IT to developing countries, the need for national IT strategies, and the adaptation of IT diffusion programs of advanced economies to the conditions of industrializing countries. As a developing country, India faces pervasive forms of information poverty, its infrastructure and financial services are in need of substantial modernization, and its potential for exporting labor-intensive software and information services is very promising. Although the significance of IT and the specific design of national IT strategies and programs are likely to vary among developing countries, some elements are expected to be similar. Moreover, differences among programs and variations in country experiences should enrich the options and instruments available for developing countries to exploit the opportunities and cope with the challenges arising from the ongoing information technology revolution. This study thus explores the strategic issues and specific options facing India’s informatics sector and, at the same time, provides a model or case study of developing national IT policies and strategies for other developing economies.
The Potential for IT in India

India can become an important player in the global information industry by the year 2000. By marshaling its vast human, industrial, and technological resources to expand its software sector—the engine of the information industry—India can raise the productivity of domestic manufacturing and services. It can also capture a far greater share of the $360 billion global software market and the $1 trillion global IT market.

With a compound annual growth of almost 30% between 1987 and 1991, the Indian software sector has expanded almost twice as fast as the world-leading U.S. software industry did during 1984-87, though from a small base. There is now a critical mass of more than 700 software firms in the country. A few large companies, such as Tata Consultancy Services (TCS) and Computer Maintenance Corporation (CMC), have state-of-the-art technical capabilities.

The Indian IT industry, particularly software, has an impact far beyond the sector. It has been a source of dynamism and technological innovation. It has provided demonstration effects for other industries, in terms of export-orientation, strategic alliances and foreign investment. It has been building India’s image abroad in terms of entrepreneurial and technological capabilities. It has been India’s window on the ongoing global technology revolution. It continues to provide a strong domestic voice for liberalization and competition. And it is likely to be a major channel for modernization and technological change throughout the economy.

Along with its critical mass of software suppliers, India has an enormous pool of potential users. Well-established capital-goods, consumer electronics and pharmaceutical industries, large transport and distribution networks, and a growing financial system constitute a substantial source of potential demand for software. Closer interaction between the software sector and these large users would create a virtuous circle that would lead to the creation of new software products for local productivity enhancements—and for export.

India could also become a major supplier of IT applications that address the common needs of developing countries. Already, India has developed innovative applications in railway reservation, irrigation control, agricultural extension, medical diagnosis, geographic information, and various expert systems. In many other areas, it could leapfrog traditional methods by finding new ways of delivering the massive social and extension services its population requires, such as distance learning and village information utilities. Given India’s know-how and the low sophistication of IT users in many developing countries, India could deliver successfully developed computer applications, training, maintenance and consulting services that would be highly relevant to the needs of other developing countries.

Another plus for India is having one of the largest scientific and technical cadres in the world. Indians have a worldwide reputation for mathematics and computer programming, and this cadre is critical in the diffusion and customization of software across many institutional and industrial settings.
But only as IT is diffused more broadly and a critical mass of domestic users is developed will the promised benefits be realized. And the acquisition of technological capabilities, particularly for new generic technologies such as IT, requires conscious adjustment and sustained effort on the part of the user and among users and suppliers. In addition to an appropriate incentive framework, the response of potential users of IT depends on information, finance, skills, and infrastructure. While the final capability building and institutional learning to exploit the power of IT takes place inside user organizations, users have to depend on external sources for critical inputs that they cannot create easily and economically. Each of these inputs has its own markets and each may suffer from market failures. That such market failures exist is borne out by the fact that all industrial countries and NIEs have invested in setting up specific programs and institutions to support the functioning of the skill, capital and information markets that are relevant to IT development and diffusion. These programs rely on inducing potential users to adopt emerging "best practices" in IT investment and management, through information and educational services, R&D and training incentives, and the subsidized use of specialized consultancy services. The experience of these countries suggests that carefully designed policies and programs can accelerate technological mastery and deepening, and can thus produce high rates of industrial development and economic modernization.

In India, these necessary adjustments are likely to be difficult. Inadequate policies and management skills slow down the adoption and lower the benefits of modern information and communications systems. A substantial lack of awareness exists of the potential benefits and associated costs of IT, particularly among small and medium-sized enterprises and public institutions. The physical and institutional infrastructures for IT diffusion are at an early stage of development. All this could change through the development of appropriate policies, infrastructures, and capabilities to adopt best practices in IT investment and management.

The Costs of Inaction

Given its strategic assets, India is (potentially) well-positioned for global competition in software services, the core and most promising segment of the IT industry. But efforts to formulate and launch a program to achieve that leadership have so far been fragmented. The activities of various ministries and industry associations need to be coordinated and strengthened through a coherent national strategy—to broaden the domestic market, facilitate the development of a competitive software industry, and build the necessary policy framework, infrastructure, and institutions.

The costs of inaction would be high. India has a window of opportunity that may not stay open long. Given the fast pace of the IT industry, India could lose its market share in a few years. Many low value-added activities of the software development process are being automated in OECD countries, and new software productivity and quality-enhancing tools may erode the competitive advantage of India's low wages. Lacking domestic demand and an infrastructure for information technology assimilation and diffusion, India is losing many of its talented software engineers. Sixty percent of IIT graduates in computer science leave for jobs overseas, and similarly high percentages of employees leave India's largest exporters of software. Moreover, other industrial and developing countries are targeting the IT industry and adopting aggressive marketing and capability development programs. Singapore and China have
teamed up in Softech I to pool Singapore's strengths in applications software with China's pool of low-cost computer professionals. Korea has set a target of $6 billion in annual software exports by 1996. Given such initiatives, India needs to respond soon with a coherent strategy that builds on its distinctive competencies—or leave itself at a significant disadvantage.

The costs of inaction will be even higher for the rest of the economy. The continuing low adoption of IT and associated managerial practices will put businesses at a competitive disadvantage. International business practices are changing in fundamental ways, with the help of modern information and communication systems, placing ever more stringent requirements for reliable deliveries and customized services in increasingly shorter time intervals and with low reject rates. As these practices are becoming pervasive in OECD markets, they are likely to dictate much of the future participation of developing countries in trade and manufacturing. Unless modernized, India's infrastructure will increasingly become a binding constraint for the entire economy. Check clearing within India takes up to 6 weeks, instead of 6 days. About 10 percent of the values of traded commodities is spent in paperwork at the ports. When effectively applied, IT benefits have been often dramatic. For example, automation of the railways reservation system, which handles over 11 million passengers a day, has reduced waiting time from 80 minutes to 5. Substantial improvements in India's information and communication infrastructure are needed to build a flexible fast moving economy.

India's economy also suffers from prevailing information poverty and uncertainty. The substantial data resources of India are tied up within public institutions, unprocessed and unused, even though the private sector and the public at large are required to supply substantial amounts of data that often leads to high transaction costs. The small fraction of public information disseminated is in paper format, severely reducing its value for other government agencies and for potential private information retailers. Legal and regulatory information are in short supply, and judges, litigants, and those in business and government often operate blind. This results in considerable delays in courts and uncertainty and unpredictability about rights, obligations, and potential liabilities. Information asymmetry between suppliers and users of public services often lead to corruption and major uncertainties. At present, the entire control of land ownership information is with a minor village official, and modernizing and updating such records assume special significance with increasing transactions and services in the rural economy. As India liberalizes and opens up its economy, information problems and slow transactions could generate significant losses and bottlenecks, and undermine participation in the information-based global economy. Equally important, information scarcity leads to policy mistakes, poor decision-making, slow learning processes, barriers to foreign investment and joint ventures, and narrow participation in the development process.

India is already investing substantially in data collection and processing and in IT hardware and systems development. These investments are likely to increase, regardless of whether a coherent IT strategy is adopted. The challenge is not merely to apply and diffuse IT into key sectors. It is also to rationalize public expenditure on data collection and processing,

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1 The public sector accounts for approximately two-thirds of the market for hardware, peripherals, and communications devices. Public sector hardware investments have traditionally been biased toward larger and more expensive systems—mini and mainframe computers, although a process of diffusing smaller computers and distributed networks of personal computers is now beginning in the public sector.
to facilitate appropriate IT investment in the private sector, and--perhaps most important--to build local capabilities that ensure the effective use of IT investments and get the most benefits from them.

Without concerted actions to draw on international best practice, India's growing investments in IT could be wasted. The effective use of IT requires the building of local capabilities, learning processes, demonstration projects, and consultancy and support services. It also requires cooperative links with international IT suppliers. And it requires appropriate policies and incentives to reduce learning costs and risks of new technology adoption and a national infrastructure to facilitate adoption and fully realize the potential benefits.

**Current Constraints**

Despite some areas of strength, India's ability to establish a long-term, vibrant IT industry, and to promote wide exploitation of information technology in support of export and modernization, is constrained by several major and interdependent problems:

- The *policy* framework is poor. Despite recent policy improvements, import restrictions and tariffs on personal computers and software remain extremely high, by international standards. Public procurement practices undervalue software and support services and favor procurement from two public corporations. The public sector lacks information systems standards. The private sector does not have easy access to public information resources. The legal protection for software is weak, and there is a narrow focus on software exports.

- The gaps in the quantity and quality of IT *manpower* to serve both export and domestic demand are growing, exacerbated by the brain drain. There are severe shortages of software engineering and project management skills because of body-shopping practices and the limited output and low quality of IT graduates from most public institutions. The quality of private training institutes is uneven. Software firms and user organizations, particularly small ones, invest little in training.

- *Data communications* infrastructure and network-based value-added services are rudimentary, due in part to barriers to entry by the private sector. The terrestrial public telecommunication network is inadequate, as are satellite and other alternative communication networks, because of the large investments they require and the low priority telecommunications has been given over several successive development plans.

- The *use of Information Technology by the public sector*, including commercial banks, is limited and ineffective due mainly to poor planning and coordination in information systems and databases. Other reasons include the under-investment in software and support services, the low awareness and computer literacy of public administrators, the neglect of complementary investments in training and institutional adjustments, and the diffused mission of the National Informatics Center.
• The use of Information Technology by private organizations is also limited, particularly among small and medium enterprises. Reasons: Awareness of the potential benefits is low. There is reluctance to use management and IT consultancy firms for intangible services to diffuse best practices in IT adoption and management and to facilitate the corresponding institutional change and the redesign of business processes. Nor are there relevant extension and support services—or strong user associations to articulate interests of users and facilitate communication with suppliers. Local suppliers invest little in user education and market development and there is a stark asymmetry in knowledge among IT suppliers and users.

• Software firms are deficient in marketing, productivity, and quality, mainly because of the predominance of small software houses with limited capacity for marketing and in-house training. Financial institutions are not prepared to deal with the intangible assets and unfamiliar markets and risks of software firms. There are few sources of assistance for quality improvement and market development. Access to software productivity tools and up-to-date technology platforms is limited, as is access to international expertise and information on overseas markets. Although awareness of software firms concerning quality and marketing has increased in the last few years, the high upfront learning costs are an obvious barrier.

These constraints should neither detract from the recent policy reforms nor from the substantial technical capabilities and progress achieved in IT use in different segments of the economy. The use of information and the diffusion of IT are inevitably conditioned by social and cultural factors which are relatively slow to change. India’s institutions are very complex and diverse, and IT use is strongly influenced by these diverse management and organizational cultures. Information and communication needs of different sectors and ministries are also heterogeneous, and responsibility for IT investment planning and information resources management is inevitably a line management function. Some industrial managers and information systems specialists are attempting to overcome the constraints to IT introduction and effective use, and some have made impressive progress. But a coherent national strategy to improve the overall enabling environment and national support infrastructure for IT could certainly enhance individual managerial and institutional efforts and help spread their best practices. Moreover, India’s recent policy improvements and capability developments should be assessed in relation to India’s potential and the aggressive strategies adopted by competitors in this strategic sector.

The Need for a National Information Technology Strategy

A coherent IT strategy can clarify government priorities and guide foreign assistance. Such a strategy would have to be based on clear understanding of the potential of this technology for revitalizing traditional industries, creating new services, modernizing key sectors, and improving public management. It would not be enough to increase the supply of IT. It would be also essential to build user capabilities to manage and invest in IT, to develop user-responsive expertise, and to integrate systems and solutions for users. Demonstration projects, enabling infrastructures, and a critical mass of organized users are typically the route to a stronger and broader domestic market—the learning ground and springboard for software exports. The thrust
of the strategy should be on the domestic use of IT to enhance India’s international competitiveness and key public services.

In developing its strategy for IT, India can benefit from what OECD countries and such NIEs as Korea and Singapore have learned about national policies and programs to develop and diffuse IT throughout their economies. Their experience suggests that government can—as user, regulator, and catalyst—influence the successful and cost-effective use and supply of IT.

Almost all OECD governments have policies and programs to promote the development of software (and microelectronics) and accelerate the diffusion of IT applications, particularly among small and medium-sized enterprises. There is widespread acknowledgement that market failures and lags in market adjustments—particularly in IT, where information asymmetries and skill and institutional adjustments are substantial—can justify carefully structured and monitored public interventions. National programs have been designed to motivate and reduce risks and learning costs for early adopters, to create a critical mass of suppliers and support services, to promote local adaptation and exports, and to widen the pool of skills. Government initiatives have created supporting infrastructure and mobilized finance for (the predominantly small) software firms.

Experience suggests that government can serve most usefully as a catalyst. But it does not need to assume all responsibilities for IT diffusion. The focus should be on market-enhancing policies. The scope is great for using private consultancy services, professional and industrial associations—and for hybrids of private and government agencies—to diffuse best practices and deliver support services to small- and medium-size users and new adopters of IT applications. Cost-sharing schemes have often been used in OECD and the NIEs to accelerate and induce private investments in IT-based modernization, diffuse best practices, promote firm-based training, and develop market-responsive intermediaries.

In addition, governments have carried out targeted programs to exploit IT to modernize public administration services, improve communication and access to their substantial public information resources, and reduce transaction costs between public and private agents. As the largest user of IT in most economies, governments have used their public computerization programs to build key elements of a national information infrastructure, generate demonstration effects, and create demand and competitive markets for local IT suppliers and support services.

Consider Singapore: It formulated a national IT strategy under the leadership of the National Computer Board and with extensive involvement of the Economic Development Board, interested government ministries, business associations and universities. The six main elements of Singapore’s strategy are:

- **Policies and institutions** such as establishing National Computerization Committees, and standardizing key technical and information areas (Electronic Data Interchange, software development process).

- **Skills development** through computer literacy in schools, broad-based civil service training, computer science education in universities, and specialized software training institutes (with assistance from multinationals).
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- State-of-the-art *telecommunication* services at internationally competitive rates.

- Large-scale *demonstration projects* such as civil service computerization program, and the creation of TradeNet to link ports and customs to importers, exporters, freight forwarders, cargo agents, and shipping agents. The return on investment for the first phase of the civil service computerization program was 170%, due to better revenue collection, new services and productivity increases. Savings for traders from TradeNet use are about one billion dollars annually.

- *Software industry development* through enforcing copyright laws, providing specialized financial services to small software enterprises, promoting joint-ventures with multinationals, establishing innovation centers for technology transfer, and supporting innovative software product development.

- *Promoting IT use in small enterprises*, through cost-sharing for consultancy services, sectoral surveys to identify common needs, and funding for developing common software packages for these needs.

**Towards a Strategy**

Drawing on international best practices, India may consider the following six areas for strategy development and action planning:

- *Formulating IT policies and building IT institutions* to increase competitiveness and standardization in public procurement of information systems, enhance access to public information and databases, and create competitive markets for information services. A national IT strategy would consider strengthening the key institutions for IT—to provide strategic and policy leadership, coherence among IT-related policies and programs, decentralized capacity for implementation and innovation, strong links between suppliers and users, partnerships between public agencies and private associations, and capabilities for experimentation, monitoring, and evaluation. India may review Singapore's experience with the National Computer Board and adapt this model to the Indian context. The role of DOE should change from regulation to promotion. Such a strategy would also address those policies and procedures which restrict access to imported hardware and software, such as high tariffs, and multiplicity of taxes and customs and licensing procedures. It should actively recruit IT multinationals to localize production in India and to build strategic alliances with domestic suppliers.

- *Developing IT manpower* by expanding and upgrading selected public educational institutions and linking them to local software industry and foreign universities. Professional and trade associations may also be mobilized to set standards and improve the quality of private training institutions. Government may explore various incentives and financing schemes to promote in-house training by software firms. Government may also consider schemes to encourage multinationals and leading local software firms to provide high quality education in software engineering, target
priority end-users for training, and promote greater interaction among IT companies and training institutions.

- **Developing the data communications infrastructure** to facilitate contact among software developers and local users and among Indian and foreign software firms for export—and to develop distributed IT applications that are urgently needed by government and financial institutions. One option is to create a public-private utility that would make lumpy investments and take the associated risks unlikely to be taken by the private sector alone and requiring a private-public partnership. To accelerate its commercial viability, a significant part of capacity could initially serve the government and the banking system. Other near-term solutions to the data communication constraint should be systematically examined, including the expansion of NICNET, and support to public-private initiatives of some states such as Maharashtra to establish a state-wide network for businesses and universities. The tariffs structure for international data communication is prohibitive for small and medium software firms; VSNL may consider its restructuring. The government may also explore policies and standards to facilitate communication among various data networks and evolve a national high speed data communication infrastructure. Broader reforms of the telecommunications sector could certainly accelerate the development of a national information infrastructure.

- **Modernizing information and transaction systems in the public sector** to complement the ongoing policy reform process and improve transactions between government and business. Priority areas for computerization may include tax administration, customs and excise duties, trade data collection, and public expenditure management. The development of such major applications should be open to competitive bidding. Government may also consider promoting the standardization of public information and the development of strategic databases, and the diffusion of best practices among public agencies in the areas of system design, technology selection, procurement, operation, and maintenance, and end-user training and support. In this context, the role and capabilities of the National Informatics Center, the Government's arm for public data collection and dissemination, should be critically appraised and enhanced.

- **Modernizing financial systems** to exploit the power of modern information and communication systems in improving financial services, portfolio management, and banking supervision. A national strategy for computerization of financial institutions would anticipate the policy, human and organizational changes required to exploit the full potential of IT in improving financial services and the management of financial institutions. A national strategy would also design IT diffusion programs in ways that would also mobilize demand for software and consultancy services and promote specialization in the potentially large market for financial systems development. Examples of priority banking applications are payments clearing systems, interbranch funds transfer, transfers between corporations and major bank branches, foreign exchange and trade transactions, linking major stock exchanges, and internal management information systems. A modern automated payment system could become the core of a broader infrastructure to provide value-added financial services, including in insurance, stock exchanges, and off-shore financial services.
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- **Promoting the production and use of IT by the private sector.** The Government may review the experience of OECD and East Asia NIEs in facilitating the adoption of promising IT applications by small and medium-sized enterprises—organizing and increasing the bargaining power of local industry users. A national strategy for India may also pilot programs to meet the special financial needs of software firms, mobilize local consultancy services to improve the quality and productivity of software houses, and promote marketing and strategic alliances between foreign and local software companies. Diffusion programs would also induce the use of local and international consultancy services (through cost-sharing arrangements) to raise awareness and promote best practices in the adoption of promising IT applications by small- and medium-sized enterprises.

It should be recognized that IT is an emerging industry and infrastructure in a developing country and as India, with severe data limitations and embryonic policies and programs. The sector does not lend itself to long-term and detailed blueprint plans. Many of the options described are therefore derived from extensive consultations with experienced local suppliers and users, and from emerging lessons of experience with IT diffusion policies and programs of the OECD and NIEs. These limitations should not detract policy makers from setting the strategic directions for the sector and exploiting the current "window of opportunity" for India’s IT industry. What is needed is a national consensus on the vision, the broad directions for change, and the commitment to act, and that seems to be emerging. The elements of a national strategy would require further generation and assessment of options for implementation, detailed design and feasibility studies, and perhaps more important, pilot testing and continuous learning from experience. In particular, programs to diffuse IT in manufacturing enterprises and financial institutions should be carefully designed, tested and phased. Program designers should align diffusion services with user needs, rely on market signals (such as user cost-sharing), exploit private-to-private delivery of technology extension services, and draw on other lessons from successful programs in OECD countries and NIEs.

**Roles for Private Sector and Government**

Successful IT strategies typically rely on complementary roles for the private sector and the Government. For India, the private sector would be the primary beneficiary, especially those small and medium enterprises in sectors where IT and IT-based services would be critical to competitiveness. Public services and infrastructures of high priority for computerization would be those critical to reducing transaction costs for the private sector. Measures to improve quality, productivity, marketing and product development among software houses may be cost-shared with the private sector and perhaps most effectively delivered by local and international consultancy firms. Similarly, measures to diffuse best practices in IT investment and management would be carried out by the private consulting industry and trade associations. Incentives may be provided to private training institutions to improve quality of training. Professional associations could be used to design and administer accreditation and quality enhancement programs. Thus, national IT policies and programs should be designed to induce maximum response and participation from the private sector in financing and implementing a national IT strategy.
The Government may consider three broad and complementary roles:

- To implement policies for creating competitive markets in IT products and services and for investing (or inducing investment) in data communication infrastructure, software manpower, and IT user education.

- To improve investment and use of IT resources in public administration; and to target a few large applications that would be selected to support export and private sector development, reduce transaction costs between public and private sectors, provide demonstration effects, and at the same time create markets for software development and value-added services.

- To develop—in collaboration with private sector institutions— incentives, extension services, and other market-enhancing measures and programs to address specific market failures (and externalities) in the supply and diffusion of IT, particularly for small software firms and user enterprises.
I. STRATEGIC IMPLICATIONS OF THE INFORMATION TECHNOLOGY REVOLUTION

Information technology (IT or informatics) covers all activities and technologies that involve the handling of information by electronic means: that is, information acquisition, storage, retrieval, processing, transmission and control. Information technology dramatically increases the amount and timeliness of information available to economic agents—and the productivity of processes to organize, process, communicate, store, and retrieve information. Its quantitative changes in GNP and in occupational structures have been sufficiently large to generate a qualitative transformation, often referred to as the "information economy" or "post-industrial society." This profound transformation has major implications for developing countries, as producers and users of this technology. And any national strategy for information technology development and diffusion must take into account those far-reaching but still far-from-understood implications for the global economy and for various industries and services.²

The share of information activities in national economies has steadily increased. The proportion of information workers in the working population of OECD countries averaged close to 50 percent in the early 1980s. According to a conservative estimate, the share of information workers in India was about 15 percent in the late 1980s. Where did they work? Most were in education, research, telecommunications, broadcasting, printing, publishing, and the computer and software industry. Their activities were inputs to the production and distribution of non-informational goods and services. They also provided such business services as consulting, accounting, advertising, credit reporting, and reservation systems. Such services grew at almost 50 percent a year in the United States between 1975 and 1987, from $3 billion to $130 billion. Although accounting for a small proportion of the information sector, business services have been growing very rapidly in industrial and developing countries.

This technology has the potential to transform both the processes and the products of the entire economic sphere—as well as all types of market transactions, institutional linkages, and human interactions and learning. Since nearly all economic activities rely on information acquisition, processing, and transmission, the scope for the use of this technology is unbounded. Information is the "lifeblood" of competitive markets, and improvements in information technologies are transforming whole economies into fast-moving information-intensive economies—and globalizing production and competition in many industries and services.³

² This section briefly draws on the extensive and growing development literature that deals with these issues (see bibliography). This literature is mainly derived from the experience of industrial countries and a few newly industrialized economies (NIEs). See, for example, C. Freedman, Technology Policy and Economic Performance Lessons from Japan, University of Sussex, 1987 and N. Hanns, The Information Technology Revolution on Economic Development, Staff Working Paper Series 120, World Bank, 1991.

³ For a broad and popular appreciation of the pervasive impact of information technology, see Alvin Toffler, Power Shift (1991).
Information technology offers opportunities for "technology blending" through capital-saving organizational and managerial innovations. It can be introduced as a modification to existing equipment or to blend new service routines and innovations with older manufacturing processes. For example, IT users can take advantage of multi-sourcing, just-in-time procurement and manufacturing, flexible production, real-time monitoring of processes and transactions, global procurement, and electronic franchising and retailing.\(^4\)

Knowledge and ideas are at the heart of the development process, and informatics has been transforming the processes of research, education, learning, publishing, and knowledge generation, transmission and retrieval. It is creating global communities of researchers, scientists, engineers and educators. Electronic and computer-aided publishing are changing the nature of today's printing, distribution, graphics, photographic, writing and allied industries.\(^5\) Informatics presents major challenges to the education systems and offers vast and new possibilities for learning, such as accelerated, tailored, and distance learning.\(^6\) It also holds a great promise for empowering knowledge workers and communities, for capturing and mobilizing local information resources, for plugging into the growing global knowledge base, and for alleviating the pervasive uncertainties and information problems that face developing countries.

The major actors in industrial countries--firms, governments, and such multilateral agencies such as OECD and the EC--believe that their future position in the international market depends on the rapid development of national capabilities to produce and innovate with information technology.\(^7\) Their combined and collaborative efforts have led to massive R&D investment and the creation of indigenous informatics industries and capabilities. And they are now paying greater attention to policies, infrastructure, and human resources for the broad diffusion of this technology through established and new industries.\(^8\) These efforts and those of NIEs such as Singapore, Taiwan and Korea provide important lessons for India. Despite the uncertainties and despite the lack of a detailed blueprint, developing countries cannot afford to miss or ignore the ongoing information revolution.

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\(^7\) For an early recognition of this trend see the whole issue of *World Development*, Vols. 13, No.3, 1985. A forthcoming special issue of *World Development* vol. 20, no. 12, 1992, has focused on the diffusion of IT and the role of government in accelerating this diffusion process.

The experience of the most successful industrializing countries suggests that governments can influence the use of IT through its role as an investor and consumer, and as catalyst, strategist or regulator. As an investor, the government continues to have an important role in the development of information technology manpower, telecommunications infrastructure, specialized R&D institutions, software parks and teleports, and other IT-related infrastructures and institutions. Governments are dominant consumers of IT in all countries, and their procurement practices are influential in determining standards, domestic competition, common adoption practices, and in general, the pace and character of IT use. As catalysts, governments have designed mechanisms and programs to speed up the learning and diffusion process through demonstration projects, subsidized consultancy services, and training and information services. Most OECD countries and NIEs have introduced a special set of programs that focused on the modernization of small- and medium-firms. The larger countries have also targeted the electronics hardware for promotion as a strategic industry, although there is a growing recognition that software is now the fastest growing and most profitable segment of the IT industry, and thus a clear shift of support towards software services and diffusion capabilities. Governments have also actively recruited high growth information companies from abroad and provided incentives and engineered strategic alliances to selectively and rapidly build local IT capabilities.

A further and, more significant, role of the government arises if coordinating the different facets of IT is critical to capturing externalities and encouraging private investment in the development and diffusion of IT. In East Asian NIEs, in particular, governments have played such a role by investing simultaneously in specialized education and training, demonstration projects (such as civil service-wide computerization; inter-ministry networking, trade and financial networks), telecommunications infrastructure, and technology diffusion institutions. By acting on a broad and coherent strategy, governments in these economies have sought to create an environment conducive to private investment in and effective adoption of IT. The different implementing agencies (public and private) were able to act in concert, exerting significant peer pressure. The various programs served to demonstrate how the different elements of IT (hardware, software, training, infrastructure, standards, management) could be judiciously brought together in a given project, making successful implementation more likely.10

9 Much has been made over the past few years of the transformation of the information technology industry from providing hardware to offering software and services. The year 1990 was a watershed in this regard: for the first time, worldwide spending on software and services equaled spending on hardware (both systems and data communications). This trend is expected to continue over the next decade, with packaged software and professional services growing in importance. As a result, the policy and institutional framework must support industry efforts to mobilize resources for an increasingly complex and specialized business with large projects, large systems, sophisticated telecommunications networks, distributed systems, and the like.

10 See Annexes 5 and 6 for OECD and NIE country experiences. A study of OECD countries and NIE’s programs to promote IT diffusion is almost completed by the ASTTP Division, and is expected to provide guidelines and best practices in designing such programs for developing countries.
How should developing countries respond to the opportunities and challenges of the information technology revolution? How could they adapt the lessons of experience of OECD countries and the NIEs to their own conditions? The answers are far from simple. This paper focuses on India as a case study in addressing the issues and options for a national information technology strategy formulation. As a developing country, India faces pervasive forms of information poverty, high transactions costs, slow moving logistics, poor financial services, and underdeveloped infrastructures. Yet, India has significant potential both as a user of the new information and communication technologies and as an exporter of the global, labor-intensive and fast-growing software and information services industry. The study thus explores those specific issues and options facing India’s informatics sector and, at the same time, provides a model of formulating national IT strategies and programs for other developing economies.
II. INDIA'S NEEDS AND OPPORTUNITIES FOR INFORMATICS

India's new policies for trade and industry make information and communication services a key need for both businesses and Government. IT applications are a source of major productivity gains and quality improvements throughout finance, manufacturing, infrastructure—as well as in agriculture, education, health, and public administration. Exports increasingly depend on timely market information, on computer-assisted product design, and on global electronic procurement and subcontracting. These practices are guiding foreign investment, technology transfer, and outsourcing. India cannot risk falling behind in adopting these business practices that have become essential to industrial competitiveness and economic modernization.

Logistics and Infrastructure

Informatics is integral to the management and effective supply of infrastructural services. Ports, railways, airways, private truckers, national distributors and retailers, increasingly depend on electronic systems for processing transactions and monitoring goods movements. Power distribution, telecommunications, and other infrastructure also depend on software applications and control systems for productivity and quality improvements. Such applications, while costly, could ultimately reduce the immense investment requirements for infrastructure and logistics in India. They could also help integrate India's huge but fragmented domestic market. Above all, they are essential for global competition, with the added benefit of conserving energy and environmental resources.

About 10 percent of the value of traded commodities is spent in paperwork and going through required procedures: 118 pieces of paper are needed to get a consignment to its destination, and for export clearance, 258 signatures are required. These cumbersome practices add substantial costs to traders and manufacturers, and result in excessive delays, inventory costs, and lost opportunities. Meantime, computer-aided "paperless trading" is taking hold in OECD countries and in the trade centers of Asia. Improved information and communication systems are often used to fundamentally redesign and streamline the customs and trading documentation process as well as the rest of the transport and distribution swapping information on markets, freight rates, ship movements, and available capacities in ports, railways, trucking, and customs services.

Consider Singapore: It established TradeNet to facilitate the electronic submission of trade documents by traders to the various government agencies, and the responses from these agencies to the sender. TradeNet also enables the agencies to interchange trade information and documents electronically to speed port operations, cargo clearances, management information,

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and statistics gathering, and the approval of imports and exports. Documents that once took a
day to process (in Singapore) are now cleared in 15 to 30 minutes. Savings for traders from
TradeNet are estimated at one billion US dollars annually. TradeNet has obviously increased
the efficiency and competitiveness of the Singapore trading community. It has also induced
small businesses to computerize.

Several large on-line transaction systems have been implemented in India, including the Railway's passenger ticket booking system and the Indian Airlines passenger reservations and departure control system. The railway's application, carried out by a local software company (CMC), provided a demonstrated effect of IT's contribution to improved services for more than 11 million passengers a day, more than the total population of Belgium. It has reduced waiting time in the reservation queue from 80 minutes to five, and is reducing corruption as well. What's next? Substantial improvements remain to be realized in the management of railways, and the Railways recently proposed computerizing freight and equipment tracking. Similarly, computerization of the Bombay Port and other major ports and customs is an imperative for expanding exports and attracting foreign investment. Moreover, national distribution systems for such basic inputs as fertilizers and for basic foodstuffs could benefit substantially from improved databases and from computerized decision support and monitoring systems.

Social Applications and Public Administration

Despite the information intensity of public administration and services, informatics use in these areas typically lags behind business applications. The opportunities for social applications are significant in India, but little public investment has been targeted to them. Moreover, some of the most promising applications already developed in India have not been commercialized or widely disseminated.

The tightening of the national budget and the accelerated pace of policy changes have increased the demand for policy analysis, transparency, expenditure control, and program monitoring and evaluation. They have also heightened the need to reduce transaction costs between the public and private sectors and to modernize major public transaction processing systems. Key candidates for such modernization programs are customs, tax administration, land records administration, and state treasury management. These programs would provide substantial downstream effects and clearly increase the productivity of key government operations.

1On-line transaction processing is the computer processing of data relevant to individual business transactions at their time of occurrence. Typical applications include reservations processing, point of sale applications, telephone switching, order processing and distribution, sales management, port information, materials handling, equipment tracking and control, etc.

The National Informatics Center (NIC) has developed some innovative and highly relevant social applications in rural health care, rural development, employment and labor market, public distribution of food and civic supplies, education administration, natural resources management, district administration, and public information. Some of these programs have improved the availability of information at central agencies, such as the Planning Commission, but the accuracy and completeness of data are major problems. The Indian Institute of Management at Ahmedabad has initiated pilot projects in the Sundernagar district of Gujarat to use information technology to change the planning and monitoring of important rural development programs. A few states have established State Computerization Committees to assist in technical matters relating to the introduction of information systems. But considerably more experimentation is needed to improve the collection, sharing, and use of information to support district decision-making and service delivery.

There are other examples of trying to wrest the benefits of IT investment in public administration. Karwar District in Karnataka State has a pilot project to use computer technology in project monitoring. The district administrator re-allocated funds for a jeep to purchase a microcomputer, and after one year, Karwar District moved from 18th to 3rd rank within the state in implementing its development programs. As a result of this success, a Computerized Rural Information Systems Project (CRISP) has been expanded to other districts to provide local officials with monitoring systems. Since then, central and local administration have undergone a learning process with profound implications for future administrative reform and for the decentralization of planning and implementation of national programs such as the Integrated Rural Development Program (Box 1).

Another example is an irrigation project authority that has developed software for use in the design of more than 1,500 kilometers of canals, with cost savings of 7 percent over manual design. Most of the engineers use the software because it saves time in estimating earth works. Manual estimation for preparing tenders used to take 9-12 man-months, a task now done in 2-3 days. The savings in engineering costs and accelerated procurement are, of course, substantial.

Government operations, especially project management, can benefit greatly from reliable data and information sharing. Constant monitoring and review—and timely instructions for corrective measures for thousands of projects in each state—can be achieved only with information at the grass root level. Transparency and open access to information increase productivity and financial accountability of irrigation and other dispersed works—which account for about 40 percent of the Eighth Five-Year Plan outlay, estimated at $175 billion.

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Box 1: Introducing Computerized Information Systems
To Improve Integrated Rural Development Program Management

In the mid-1980s, GOI realized that a massive amount of data had been collected for managing the Integrated Rural Development Program (IRDP) but that not much of it had been used effectively for micro-level planning and implementation at the district level or for policy making and monitoring at the state and central governments. A pilot experiment at the Karwar District that introduced computerized decision-support systems resulted in a marked increase in the district's performance, by improving efficiency of report generation, enabling officers to devote more time for vital extension duties, and improving access to accurate and timely data for decision making and monitoring. Success factors included: management ownership, adequate training and effort to modify inefficient procedures. Based on this experiment, the Computerized Rural Information Systems Project (CRISP) was extended to the whole country in 1987.

In the early phase, 1987-90, CRISP was developed by the center as an overlay to the existing IRDP manual monitoring system, and did not reflect the reality of the local environment. Historic tensions that had existed between the center and the state were further aggravated by a system design process that did not involve consultation with state governments and district administrators concerning their requirements. Efforts to computerize were also hampered by inadequate initial training, poor user interface (in English rather than Gujarati), alienation of directors of the district rural development agencies, the shortage of dedicated staff for data entry, poor accountability and monitoring of computer maintenance companies, and the lack of a data-sharing culture. Regular reports still had to be produced manually.

Since 1990, the center began to recognize the need to address the institutional and human resource issues involved, as well as the sources for resistance to change. Central and state governments convened to explore the creation of a separate computer cadre within the administration. The sheer presence of the microcomputer at the district agencies has prompted curiosity and self-learning among local administrators. State-level support to end-user applications further triggered initiatives from many local agencies to provide a local infrastructure for end-user support. Most local agencies now indicate that the computer has reduced the time required for preparing their monthly reports by half. Some districts are begging to identify useful categories of information for planning and monitoring purposes and are contemplating the use of independent marketing agencies to collect ongoing data on productivity and income of rural poor households. The trend towards end-user computing applications has also triggered changes in the normal functioning of IRDP administration. In some districts, the director has decided to generate more accountability and involvement in IRDP implementation among extension workers. Rather than measuring aggregate targets, the performance of each village-level worker will be monitored based on the extent to which each village in his area has been uplifted. Local initiatives in computerization have also brought about changes in the working-group relationships. For example, junior officers are starting to perceive the value of computers in bringing them into direct contact with the director to discuss potential computer applications for their agencies.

Gradual change has been underway in the perception of information technology as a tool for IRDP management by administrators at all levels. New uses of IT at the district level are emerging, quite apart from the intentions of the original designer. Information technology has acted as a probe to reveal inefficiencies in basic administrative processes and organization and has begun to be used as a vehicle for promoting change within public administration. This process is still at an early stage. The existence of both opportunities and threats in applying IT for development planning and implementation suggests that the process of change needs sensitive and informed management, which should take into account the complex web of socio-political and cultural factors in development administration.


The legal system -- essential to private sector development and to effective public administration and governance -- could also benefit from IT. Judges, litigants, and those in
business and government often operate "blind" or with incomplete and unreliable information about the rules that govern transactions. This results in considerable uncertainty and unpredictability about rights, obligations, and potential liabilities. India has one of the largest bodies of rules and regulations in the world. Yet there is no organized or effective legal information system which if automated would do much for governance and private sector development.

Financial Sector

The financial sector is one of the largest markets and earliest adopters of information technology, and in many countries financial applications have been a driving force for the development of a large local market for informatics. In India, however, numerous constraints have retarded the adoption and productive use of modern information and communication systems by financial institutions and insurance companies. To begin to loosen these constraints, the Reserve Bank of India has carried out two studies on the use of IT in commercial banks. And interest is now growing in initiating a modernization program that would systematically use IT to redesign current business processes and services. Part of this program would be to modernize payment systems, reduce floats, improve monetary management, and provide links with fiscal planning and monitoring.

The underdevelopment of information collection, dissemination, and analysis in the commercial banking systems has had the following consequences:

(a) The opportunity costs have been high (for banks and for their clients) on large sums of money tied up as interbranch items in transit—due to a manual, paper-based system of interbranch settlements. For example, check clearing takes 6 weeks, instead of 6 days! The opportunity costs for individual banks are also high because of largely manual interbank payments settlements. Transaction balances maintained by banks and their clients tend to be higher than if the settlement mechanisms between banks and branches were more efficient and automated.

(b) The possibility of fraud (and delayed discovery of fraud) is another byproduct of manual, paper-based systems for processing transactions. A major area of concern in some bank branches, this danger is now extended to the nascent and fast-growing stock markets. With timely information, the $2-3 billion stock market swindle might have been forestalled.

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15 Ancient Hindu and Muslim law; British colonial law; hundreds of laws enacted on a yearly basis by a national parliament and 26 state legislatures; decisions of one supreme court and 18 state high courts that constitute binding precedent; hundreds of thousands of regulations issued each year by hundreds of central and state level administrative authorities.

Banks have been reluctant to accept and conform to capital-adequacy ratios that are based on risk-weighing of assets because there is no precise information on their asset composition.

Portfolio management capabilities are weak because of delays in obtaining and processing information about distribution and quality of assets among branches. This problem is particularly acute for small agricultural and industrial loans where single banks as well as the entire banking system often end up over-lending to one sector in one region. The long reaction times for such lending problems add to portfolio deterioration. Portfolio diversification strategies are also difficult to put in place because the information base is inadequate. The inadequacy of portfolio information also makes it difficult for banks to resist populist lending programs.

Banks cannot precisely differentiate the costs for various financial products, instruments, and services. So, they are constrained in their ability to price services according to demand, offer differentiated products, and modulate their fee structure for these products. The results: banks underprice their fee-based services because they do not know enough to negotiate with their clients, and there is no price differentiation among banks for their financial services.

Banks cannot obtain a timely, comprehensive picture of the banking relationships of a specific firm, slowing the response to clients.

Banks cannot identify and analyze centers of high activity, resulting in poor allocations of manpower and inflexibility in switching resources. Without such information, the negotiations with unions over work allocation are inevitably difficult.

In many branches, there has been an increasing buildup of arrears in the daily balancing of accounts because the expansion of business operations has far outstripped the capacity of manual bookkeeping procedures to keep track of daily transactions. This has increased the danger of fraud, the dissatisfaction of customers, and the possibility for a complete breakdown of the checks and balances in the branch accounting system.

The opportunities for IT applications in the financial sector are thus substantial. The effective use of IT in banks could allow them to increase fee income and improve portfolio management and assessment, resource allocation, accounting control, and service quality. Better information handling would also enhance the productivity of banks, particularly when reinforcing the ongoing reforms. For most Indian commercial banks, about 20 percent of the branches account for more than 80 percent of the banking business. By focusing on these high-activity branches, the efficiency gains would be substantial.

Software applications could also enhance services through credit cards, automated teller machines, electronic fund transfers, and foreign exchange and treasury management. The growing stock markets in India are also in the process of computerizing, to speed access to information, particularly on the health of participating financial institutions. Some specialized
financial institutions, such as Industrial Development Bank of India (IDBI) and Industrial Credit Investment Corporation of India, Ltd. (ICICI), are relatively advanced and have applied IT to credit monitoring, project appraisal, funds management, and foreign currency management. But other major banks, such as the National Bank for Agriculture and Rural Development, and the majority of commercial banks are far behind in exploiting information systems for their huge branch networks and transaction volumes. Similarly, insurance, leasing, and other financial service companies lag behind, offering a large market and substantial learning opportunities for the local software industry.

The Government is well aware of the urgency to modernize the financial services, and the Minister of Finance has recently indicated the importance of updating banking technology. Despite efforts by the Reserve Bank of India, progress so far has been disappointing. Labor and management have resisted change, and institutional adjustment has been slow. The potential for developing common applications and information standards to reduce costs and learning period, and to promote common infrastructure and transactions among banks, has not been exploited. But the recent experience of the State Bank of India in initiating computerization in few of its branches suggests that there are opportunities to accelerate these processes and to share experiences with other interested banks.

Manufacturing

The competitiveness of India's major industries is likely to change as a result of worldwide diffusion of IT in both products and industrial processes. Take the case of the machine tool industry, a critical subsector of capital goods and characterized by rapid technological change. Increasing computerization in manufacturing, first through computer numerically controlled (CNC) machines, and lately through flexible and integrated manufacturing (FMS and CIM), has transformed worldwide demand and competition in the machine tool industry. The Indian industry was slow to react to this technological revolution. Most Indian manufacturers and users of machine tools let the technological revolution bypass them for a decade or so. By the time they began to react, the development of indigenous CNC systems has been beset by both hardware and software problems. Meantime, and since early 1970s, most industrialized countries have taken proactive policies and programs to foster the development and diffusion of CNC machine tools. The most successful among them, Japan and Germany, have had the most sustained and systematic programs to promote micro-electronics diffusion in their machine tools industry and factory automation in targeted user industries. Also, in contrast to India's fragmented response, where some 40 firms began to produce 29 different types of CNC machine tools by late 1980s, the Korean machine tool industry concentrated on three types of CNC machines, to achieve international competitiveness. Successful countries from both the industrialized and NIE groups have taken deliberate and orchestrated measures to ensure that their machine tool industries would adjust to and take advantage of the ongoing micro-electronics and information technology revolution.17

Fundamental changes in the management of industrial processes, in evidence throughout the world economy, have been also spurred by improvements in information and communication systems. One of the most popular applications of IT is planning a company's materials requirements and equipment use, which brings savings of as much as a quarter in assembly and labor costs and a third in inventory investment. Contributing to environmental protection as well as international competitiveness, these applications are enabling corporations to out-source more products, both locally and globally. Some large Indian enterprises that have already introduced such systems could become a source of local know-how for smaller enterprises.

Another major application area--Computer Aided Design (CAD) and Computer Aided Manufacture (CAM)--caters to the engineering industries: automotive, machine tool, heavy machinery, light engineering, electronics, microelectronics, and construction. But it is also used extensively in garments, leather, footwear, and other fashion industries, shortening the product development times by 30 to 90 percent. It has thus contributed to the significant shortening of product cycles, and increased the diversification and differentiation of products. CAD-CAM is closely tied to other IT applications in procurement, manufacturing, marketing, and distribution--promoting just-in-time manufacturing, total quality management, flexible manufacturing systems, and a host of other innovations in management and business practices.

The Indian market for manufacturing applications is still underdeveloped. The high costs of hardware and software in India (four to five times their costs to Western counterparts), the low awareness of management, the inappropriate technical support from vendors, the lack of adaptations to local requirements from consultants--these are some of the key factors limiting adoption and effective use. While IT-induced changes in manufacturing and international business practices pose serious challenges to enterprises of all sizes, they are most problematic for small and medium-size industrial enterprises in India. As with all IT applications, implementing these systems requires enterprises to introduce basic changes in business processes and operating procedures.

2.2 Recent policy reforms, including trade liberalization and deregulation, are likely to promote competition and increase the need (and effective demand) to deploy IT in manufacturing. But supply response (for IT adoption) is likely to be constrained by several market failures: information, finance and capability failures.

Carefully designed programs may effectively address these specific market failures. The Confederation of Indian Industries, the National Productivity Council, and several private associations have shown increased interest in supporting a national program to accelerate the diffusion and effective use of promising IT applications among medium-size enterprises.

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18 In the United States, CAD-CAM forms about 10% of the total IT market, compared with less than 2% of India's much smaller IT market.

19 There is a substantial literature on such market failures to the acquisition of technological capabilities, including, for example, S. Lall, Building Industrial Competitiveness in Developing Countries, Paris, OECD Development Center, 1990; Operations Evaluation Department, World Bank Support for Industrialization in Korea, India and Indonesia, World Bank, 1992.
Best practices in introducing such applications in manufacturing have emerged, and the diffusion of these practices in India could lead to productivity and quality enhancements and to stronger links among large and small enterprises. Many OECD countries and all first-tier Newly Industrializing Economies (NIEs) have developed appropriate diffusion programs to overcome market failures and accelerate the acquisition of these technological capabilities, particularly among small and medium enterprises.

Effective Use and Diffusion

National spending on computer hardware and software in India is estimated at 0.4 percent of GDP (1990), compared with software competitors—0.6 for Mexico, 0.8 for Korea, 1.1 for Ireland, 1.3 for Singapore, and 1.4 for Israel. Most OECD countries spend between 3 and 5 percent of their GNP on hardware and software. India's information sector is also smaller than other Asian countries. Total value of output of information goods and services in India is estimated at 11% of GDP, compared to 26% for Singapore, 15% for S. Korea, and 14% for Malaysia. In terms of informatics penetration into various sectors of the economy, such as manufacturing, transport, and finance, IT remains relatively marginal to corporate strategy and operations. Few small and medium-size enterprises use informatics.

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20 See Vijay Kelkar, "India's Information Economy", Delhi, February 1991.
Figure 1: Performance and Potential of IT

Figure 1 illustrates the diffusion of IT in a range of countries, including India. It suggests that access to computers and telephones in India is far below worldwide average, and far behind other NIEs such as Brazil and Taiwan. Although the figure indicates that IT diffusion is related to the level of economic development, it also suggests that the NIEs have diffused IT well ahead of others and thus used IT as a leading growth generating factor. In contrast, the low access to IT may have deprived India from exploiting its technically educated workforce to become a serious competitor in the international software market. Table 1 indicates that, compared with other Asian countries, India's domestic market for IT has been mainly in manufacturing and government administration; the share of banking and the financial sector is the lowest among Asian countries' IT markets.

The main factors behind India's underdeveloped domestic market and limited use of IT are:

- The national policy framework and strategy for IT development and diffusion are inadequate. Current policies favor local hardware manufacturers, at high costs to potential users and to software and information producers (paras 3.2-3.8).

- Public infrastructure (data communication) and private support services (consulting) are poor, reducing the return from investments in IT and information resources (paras 3.12-3.18).

- Indian hardware and software suppliers invest little in educating users, in providing professional advice, and in marketing. Most marketing is for the short-term but highly profitable activity of exporting programmers (paras 3.25-3.36).

- Until recently, macroeconomic and trade policies have led to a highly protected and regulated economy--and weakened incentives to invest in IT resources, skills, and technology (para. 4.2-4.5).

- Government procurement policies and information management practices are poor (paras 4.6-4.10). Government practices unwittingly underprice the software and support services, under-invest in complementary inputs, and discourage the development of a competitive domestic market for information goods and services. Government has not yet exploited the potential externalities from its procurement activities or the potential demonstration effects from its information management standards and practices, even though public sector demand for IT (goods and services) represents about 60 percent of the total domestic market.\(^{21}\)

- Informatics professionals lack business orientation--while business organizations invest little in understanding the technology. Moreover, computer and information literacy is scant and business managers are poorly prepared to

\(^{21}\)Worldwide, the public sector plays a central role as the largest producer of information and consumer of IT goods and services. It buys over 40% of the informatics hardware sold worldwide.
## Table 1
### IT Sales By Industry Sectors (1992)

<table>
<thead>
<tr>
<th>Industry Sector</th>
<th>Australia</th>
<th>India</th>
<th>Japan</th>
<th>Malaysia</th>
<th>Singapore</th>
<th>South Korea</th>
<th>Taiwan</th>
<th>Thailand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Government (%)</td>
<td>27.0</td>
<td>15.2</td>
<td>7.9</td>
<td>10.0</td>
<td>20</td>
<td>18.6</td>
<td>29</td>
<td>28</td>
</tr>
<tr>
<td>Banking, Finance &amp; Insurance (%)</td>
<td>23.8</td>
<td>8.1</td>
<td>26.8</td>
<td>27.0</td>
<td>27</td>
<td>25.3</td>
<td>25</td>
<td>37</td>
</tr>
<tr>
<td>Manufacturing (%)</td>
<td>17.4</td>
<td>23.5</td>
<td>25.7</td>
<td>13.0</td>
<td>16</td>
<td>44.1</td>
<td>12</td>
<td>5</td>
</tr>
<tr>
<td>Transportation (%)</td>
<td>2.3</td>
<td>11.5</td>
<td>-</td>
<td>3.0</td>
<td>9</td>
<td></td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>Distribution (Wholesale, Retail) (%)</td>
<td>10.8</td>
<td>10.1</td>
<td>9.4</td>
<td>8.0</td>
<td>8</td>
<td></td>
<td>8</td>
<td>12</td>
</tr>
<tr>
<td>Medical Care (%)</td>
<td>7.3</td>
<td>5.8</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>Service Industry (%)</td>
<td>2.0</td>
<td>8.6</td>
<td>5.5</td>
<td>4.0</td>
<td>-</td>
<td></td>
<td>6</td>
<td>-</td>
</tr>
<tr>
<td>Education &amp; Research (%)</td>
<td>3.0</td>
<td>9.1</td>
<td>-</td>
<td>3.0</td>
<td>2</td>
<td>1.8</td>
<td>5</td>
<td>-</td>
</tr>
<tr>
<td>Home &amp; Individual (%)</td>
<td>3.8</td>
<td>2.1</td>
<td>-</td>
<td>2.0</td>
<td>4</td>
<td>-</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>IT Industry (%)</td>
<td>-</td>
<td>-</td>
<td>16.9</td>
<td>-</td>
<td>-</td>
<td>7.5</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Other Industries (%)</td>
<td>2.6</td>
<td>6.0</td>
<td>7.8</td>
<td>30.0</td>
<td>14</td>
<td>2.7</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>IT Market Size (US$M)</td>
<td>$5,018</td>
<td>$880</td>
<td>$56,278*</td>
<td>$540</td>
<td>$1,152</td>
<td>$3,633</td>
<td>$675*</td>
<td>$665</td>
</tr>
</tbody>
</table>

* Japan and Taiwan’s data are for the information services industry.

Source: ASOCIO Countries.
manage the skill and institutional changes associated with the introduction of IT.

- Links are weak between local suppliers and users of IT. Domestic users are not organized to share experience, exert pressure on suppliers for quality and fair play, or to learn along with suppliers.

- Potential users are unaware of the technological options and of the best practices to realize the benefits—such as the needs to adopt new managerial practices and business processes, to undertake complementary investments in relevant training and support services, and to identify and pilot strategic applications.

- IT users are unwilling to pay for "intangible" services such as technical assistance or consulting services for planning information systems, redesigning business processes, analyzing information requirements, educating senior staff in information resource management, or providing professional advice on hardware and software acquisition. Yet, international experience indicates that hardware costs are typically less than 20 percent of the total, with the rest going for training, end-user support, and software maintenance.

Another limiting factor is the bureaucratic culture of the public sector. Indian public administration is notorious for unnecessary paperwork, excessively hierarchical management, inflexible personnel policies, and limited attention to service. In some agencies, resistance to the use of information systems is compounded by staff (particularly those in banks) who fear that computerization would lead to massive layoffs. Changing this culture calls for selective and strategic applications of IT and for complementary investments in change management. It also presents opportunities for redesigning work processes, reducing managerial layers, enhancing accountability and performance monitoring, and improving the quality of working life.

Various impediments to absorption of information technology in Indian institutions need to be systematically addressed. Fears and concerns of users manifest themselves in various forms: skepticism regarding the benefits, apprehension regarding job loss and skill obsolescence, and lack of faith in the system's reliability. Substantial user education and evolving local solutions through indigenous software development and adaptation, with close involvement of the users, is an effective strategy to overcome such impediments. To overcome management and workers' fear of the unknown, the stakeholders must be involved in the selection, design and implementation of IT applications. Skepticism over potential benefits should be tackled through strategic choice of application areas, demonstration effect and pilot projects, phased implementation, and clear articulation and management of benefits. Reliability could be enhanced through selection of simple and user friendly systems, and interaction with users to ensure common understanding of the required reliability standards. Concerns about employment impact may be addressed by management and policy makers by stressing capital and energy saving applications, and selective and phased introduction of IT. Indian institutions must
inevitably cope with the imperatives of technical change, establish forward-looking training programs, and create enabling environments for their employees to adapt to changes in their work.

Finally, the crucial link between IT (particularly software) exports and a strong domestic client base has been largely overlooked. Software exports, expanding at 40 percent annually in the past few years, are a bright spot in India's overall export performance. But an internationally competitive software industry cannot be sustained without an equally competitive (and expanding) home base for learning and competency development. Until recently, government policies and promotional efforts in the software industry have focused almost exclusively on exports of software manpower. Such exports have lower profit margins than software packages and turnkey projects and do not provide learning for high value-added skills—such as project management, systems design, and systems integration, skills that must be developed in home markets. The domestic environment for the diffusion and effective use of IT is nevertheless changing, and there is a window of opportunity to capitalize on this change and accelerate the process of building a significant share in the fast-growing global market for software and related services.22

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22See, for example: Software: An Emerging Industry Need for Developing Domestic Market, a seminar sponsored by UNDP Delhi, August 6, 1991; in particular, see articles by N. Vittal, (Secretary, DOE) and F.C. Kohli, pp. 3-20.
III. SUPPLY CHARACTERISTICS AND CONSTRAINTS

Hardware Manufacturing

The availability of computers at competitive prices is an essential pre-requisite for successful diffusion of information technology in any economy. Policy makers in many advanced economies view the computer industry itself as a "strategic industry", given that in the future, international competitiveness and productivity growth would largely depend on the effectiveness with which computers can be applied across the economy. Worldwide, computer and peripheral hardware is a US$300 billion business that has been growing at more than 10 percent a year. The main reasons for such rapid growth are, the declining cost of information processing, the proliferation of new products, and the horizontal integration of consumer electronics, communications, and computer products. Although market entry has become easier with personal computers and the widespread availability of basic components, sustained growth in this industry requires that smaller companies manage the transition from low-cost assembly (the stage the Indian computer hardware industry is currently in) to more research-intensive and design-intensive operations.

The Indian Government has been influencing the computer hardware industry since the 1960s. Government policy initially protected the industry from foreign competition through high tariffs and quantitative controls on imports. Coupled with industrial licensing requirements which severely regulated entry and exit of firms, such protectionist measures, no doubt, affected the speed and nature of technological progress in this industry. In 1971, domestic production of computers was entrusted to a sole producer—ECIL, a public enterprise. Similarly, by setting up Computer Maintenance Corporation (CMC) in 1976, the maintenance of an estimated 400 computer installations was "indigenized" following IBM's exit from India. However, due to stringent policies governing foreign collaboration with domestic computer firms, Indian firms had little access to international technology.

Policy changes since the mid-1980s fostered domestic competition, opened avenues to international and domestic technology sources, and encouraged the growth of efficient producers. On the whole, the growth performance of the entire hardware sector appears to be most impressive.23 As shown in Table 1, the value of hardware production increased at an average annual rate of 19.8% between 1987 and 1991. Production of information technology (IT) products—the largest segment of the hardware industry—increased from Rs. Billion 20.7

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23 Following the Department of Electronics, "Hardware" is defined here to include, very broadly: (a) Information Technology Products; (b) Electronic components; and (c) Consumer Electronics. The "Information Technology Products" sub-sector, in turn, comprises four main segments: (a) Computer Hardware and Peripherals; (b) Industrial Electronics; (c) Communication and Broadcast Equipment; and Strategic Electronics.
in 1987 to Rs. Billion 46.9 in 1991, reflecting an average annual growth rate of nearly 23%.\textsuperscript{24} The production of computers—the core of information technology—also registered an impressive growth rate of 22% per year during 1987-91. This includes micros, minis, superminis,

Table 2. The Hardware Industry: Production, Composition, and Growth 1987-91
(Value in Rs. Million)

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total Hardware</strong></td>
<td>47,200</td>
<td>63,000</td>
<td>83,090</td>
<td>92,000</td>
<td>97,250</td>
<td>19.8%</td>
</tr>
<tr>
<td><strong>Of which:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IT Products</td>
<td>20,700</td>
<td>27,110</td>
<td>38,350</td>
<td>44,200</td>
<td>46,940</td>
<td>22.7%</td>
</tr>
<tr>
<td>(a) Computers</td>
<td>3,750</td>
<td>4,860</td>
<td>7,000</td>
<td>8,200</td>
<td>8,300</td>
<td>22.0%</td>
</tr>
<tr>
<td>(b) Industrial Electronics</td>
<td>6,850</td>
<td>9,350</td>
<td>12,100</td>
<td>14,000</td>
<td>14,100</td>
<td>19.8%</td>
</tr>
<tr>
<td>(c) Broadcast &amp; Communication Equipment</td>
<td>7,100</td>
<td>9,000</td>
<td>14,250</td>
<td>16,300</td>
<td>19,350</td>
<td>28.5%</td>
</tr>
<tr>
<td>(d) Strategic Electronics</td>
<td>3,000</td>
<td>3,900</td>
<td>5,000</td>
<td>5,700</td>
<td>5,190</td>
<td>14.7%</td>
</tr>
<tr>
<td>Electronic Components</td>
<td>7,000</td>
<td>10,250</td>
<td>14,400</td>
<td>15,200</td>
<td>17,500</td>
<td>25.7%</td>
</tr>
<tr>
<td>Consumer Electronics</td>
<td>18,200</td>
<td>24,000</td>
<td>28,000</td>
<td>29,380</td>
<td>30,000</td>
<td>13.3%</td>
</tr>
<tr>
<td>Production in EPZs</td>
<td>1,300</td>
<td>1,640</td>
<td>2,340</td>
<td>3,220</td>
<td>2,810</td>
<td>21.3%</td>
</tr>
</tbody>
</table>


\textsuperscript{24} Information technology products accounted for almost half of total hardware production in 1991, whereas the respective shares of consumer electronics and electronics components were approximately 31% and 18%. Hardware produced in EPZs accounted for less than 3% of total hardware production.
mainframes to engineering workstations, peripherals and so on. Moreover, the pace of innovation in the computer industry has increased, and the technology gap with international producers of computers has narrowed. The entry of a large number of small and medium-scale firms in the 1980s played a substantial role in the acquisition of international computer technology and provided a seed-bed from which a number of successful firms grew to considerable size.

A closer look at growth trends, however, indicates that in the early 1990s, the hardware sector could not sustain the momentum of growth achieved in the late 1980s. Compared to annual growth rates of over 30% in the late 1980s, hardware production grew at a mere 5.7% in 1991 (Table 3). All three main segments of the hardware industry have suffered from lower growth rates in the recent past. The production of computer systems and peripherals grew by a poor 1.2% in 1991, raising concerns about the future of this key industry, and perhaps more importantly, its implications for widespread use of information technology in India.

Table 3. Hardware Production: Sectoral Growth Trends

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Hardware</td>
<td>36.4%</td>
<td>33.5%</td>
<td>31.9%</td>
<td>10.7%</td>
<td>5.7%</td>
</tr>
<tr>
<td>Of which:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IT Products</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) Computers</td>
<td>n.a.</td>
<td>31.0%</td>
<td>41.5%</td>
<td>15.3%</td>
<td>6.2%</td>
</tr>
<tr>
<td>(b) Industrial Electronics</td>
<td>n.a.</td>
<td>30.0%</td>
<td>44.0%</td>
<td>17.1%</td>
<td>1.2%</td>
</tr>
<tr>
<td>(c) Communication and Broadcast Equipment</td>
<td>n.a.</td>
<td>36.5%</td>
<td>29.4%</td>
<td>15.7%</td>
<td>0.7%</td>
</tr>
<tr>
<td>(d) Strategic Electronics</td>
<td>n.a.</td>
<td>26.8%</td>
<td>58.3%</td>
<td>14.4%</td>
<td>18.7%</td>
</tr>
<tr>
<td>Electronic Components</td>
<td>n.a.</td>
<td>30.0%</td>
<td>28.2%</td>
<td>14.0%</td>
<td>-9.0%</td>
</tr>
<tr>
<td>Consumer Electronics</td>
<td>n.a.</td>
<td>30.0%</td>
<td>28.2%</td>
<td>14.0%</td>
<td>18.7%</td>
</tr>
<tr>
<td>Production in EPZs</td>
<td>n.a.</td>
<td>26.2%</td>
<td>42.7%</td>
<td>37.6%</td>
<td>-12.7</td>
</tr>
</tbody>
</table>


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25 The computer industry made significant qualitative gains during this period. A few manufacturers introduced computer systems based on standard microprocessors with a speed of 50 MHz. There was an overall trend towards open architecture, adding more sophisticated features like higher processing powers, speed, better resolution and networking features. See Rastogi (1992), "Electronics Production and Export Profile: 1991" in *Electronics: Information & Planning*, Volume 19 No. 9, June 1992.

One of the main reasons for poor growth performance of domestically manufactured computer hardware and peripherals appears to be their excessively high prices, which have restrained effective demand for their use. These high prices are, in turn, a large extent, the result of high tariffs and other restrictions on both imported inputs as well as imported computers (paras 4.4-4.5), indicating that policy changes have not gone far enough in enhancing competitiveness in this industry. High prices of computers (both the imported as well as the domestically produced) have severely impeded effective demand for the use of computers--or in other words--the diffusion of information technology across the economy.

As far as computer hardware is concerned, India has some way to go in order to become internationally competitive. The entire hardware industry for instance (including consumer electronics, and electronics components as well) is predominantly domestic market-oriented; less than 6% of hardware production was exported in 1991. As with production, the exports of hardware witnessed a significant drop in 1991--largely due to reduced exports of IT products, which accounted for over 75% of total hardware exports in 1990 (Table 4). Concomitantly, the "export-orientation" of IT products (i.e. exports as a share of production) dropped from approximately 10% in 1990 to about 6% in 1991. Similarly, computer exports dropped from a peak of Rs. Billion 2.9 in 1990 to Rs. Billion 1.8 in 1991.

Table 4. Exports of Hardware 1987-91
(Value in Rs. Million)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Exports of Hardware</td>
<td>2,415</td>
<td>3,740</td>
<td>6,270</td>
<td>7,300</td>
<td>5,700</td>
<td>23.9%</td>
</tr>
<tr>
<td>Of which:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IT Products</td>
<td>1,152</td>
<td>1,983</td>
<td>3,410</td>
<td>4,320</td>
<td>2,710</td>
<td>23.8%</td>
</tr>
<tr>
<td>Electronic Components</td>
<td>960</td>
<td>1,280</td>
<td>2,290</td>
<td>2,140</td>
<td>1,780</td>
<td>16.7%</td>
</tr>
<tr>
<td>Consumer Electronics</td>
<td>303</td>
<td>477</td>
<td>570</td>
<td>840</td>
<td>1,210</td>
<td>41.1%</td>
</tr>
</tbody>
</table>


27 Indian microcomputer prices, for instance, were twice higher than international prices, and the prices of some peripherals are slightly higher than world prices. However, by the early 1990s, India had considerably narrowed the technological gap in computer manufacturing, and prices for modern systems are estimated by some to be not more than 50 percent above world market prices.

28 For microcomputers for instance, imported inputs constitute around 95% of the total materials bill, limiting the domestic computer industry almost completely to assembly. See V. Kelkar and K. Varadarajan (1990), "India's Computer Industry: Perspectives and Options for Latecomer Strategies," Paper presented to the OECD Development Center Research Project on "Technological Change and the Electronics Sector," Paris, May 1989.

29 The relative stagnation of hardware production and exports for 1991 may be largely explained by the domestic recession at the time, the collapse of trade with the Eastern block countries, and the fiscal squeeze on government.
Several recent trends are likely to have major implications for India's hardware manufacturing. First, the share of hardware revenue in total IT production has dropped from 44% in 1990 to 37% in 1992, and profitability is under increasing pressure with the gradual liberalization of IT imports. Second, the so-called "unorganized" sector or "gray" market share of the total domestic hardware market has increased dramatically in the last two years up to 20%; these small producers are able to assemble and sell personal computers at half the cost of the formal sector. Third, the importance of brand names is likely to increase for the corporate sector and other brand-conscious buyers, thus profiting the top five companies or so. The middle players are likely to be squeezed out, as they would neither have the economies of scale nor brand name advantage. The suppliers are thus likely to be divided into multinationals, large Indian producers and the gray market. Corporate strategy for local personal computer manufacturers would likely be to leverage economies of scale, develop dealers and alternate marketing channels, and build strategic alliances with multinationals.

Other trends are related to workstations, large systems, and local area networks. For workstation producers, the Indian customer base is likely to change significantly. Currently, R&D institutions and universities have the largest share. In the medium term, workstations are likely to spread more to the commercial sector. For these producers, corporate strategies may aim at extending application areas to the private sector and to provide better support and training services. For large and medium systems (multi-user systems), pressure will increase from distributed processing. Producers of this segment will need to position products for specific applications and develop capabilities to become systems integrators. Networks are rapidly gaining grounds in India's private sector, but the supply and demand are constrained by the availability of network specialists. Growth is likely to be driven by specialization and the increasing need for network-based applications. Corporate strategies for network suppliers may involve developing specialist groups, for various types of users or services, developing dealer channels, and linking up with other specialist suppliers to offer integrated services.

Overall, fundamental shifts in the mode of computing are proceeding world-wide as well as in India and user needs are going away from stand-alone applications. It is far from clear whether Indian hardware suppliers will be able to make this transition.

Investing in computer production is unattractive for India (and most other developing countries) for four reasons: the large investment costs; the great degree of technological risks; the massive government funding for informatics R&D in the U.S., Japan, and European Community nations; and the shift towards highly differentiated complementary goods and services—for homogeneous hardware platforms. The industry will have to consolidate under a few domestic manufacturers large enough to reap scale and scope advantages. The industry will also have to build strategic alliances with IT multinationals. There may be a room, however, for a few small producers of high quality customized computer and network-based systems. The industry needs to be pushed in these directions by appropriate trade, technology and industrial policies (Box 2).
Box 2: How Computer Manufacturers Are Adjusting to the Changing National and International Environment?

Liberalization of the Indian market and the ongoing globalization of the information technology industry are having their impact on Indian IT producers. The group of nine Tata companies, who have a large presence in the IT industry, represent an interesting case of how large domestic players are adjusting to change.

The nine Tata companies are Tata Consultancy Services (TCS), Tata Unisys (TUL), Tata Honeywell, TELCO (computer division), Tata Elxsi, NELCO (computer division), PSI Data Systems Ltd., OMC Computers and TISL (recent joint venture with IBM). These companies share common strengths: established name, good foreign tie-ups, wide product range, market reach, good professionals, and credibility abroad. They also share common weaknesses, monolithic organizational structure, slow decision-making, overlapping activities, centralized management, low innovation rate, and limited focus in domestic market. Changes in the environment are forcing these companies to examine their strengths and weaknesses, redefine their strategies and market segments, seek synergies among themselves and build strategic alliances with different multinationals. The following table summarizes their activities.

<table>
<thead>
<tr>
<th>Company Name</th>
<th>Year of startup</th>
<th>Turnover 1992-93 (in Rs Cr)</th>
<th>Foreign Collaborator(s)</th>
<th>Products/Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCS</td>
<td>1968</td>
<td>217.0</td>
<td>Northern Telecom, Oracle, McDonnel Douglas, SAS Inc.</td>
<td>Software exports, turnkey solutions, packaged software</td>
</tr>
<tr>
<td>TUL</td>
<td>1978</td>
<td>91.0</td>
<td>Unisys, AutoDesk Microsoft, SCO</td>
<td>Minis, micros, software exports, packaged software, consultancy</td>
</tr>
<tr>
<td>TISL</td>
<td>1992</td>
<td>—</td>
<td>IBM</td>
<td>Micros, minis, software exports</td>
</tr>
<tr>
<td>TATA Elxsi</td>
<td>1989</td>
<td>17.1</td>
<td>Silicon Graphics</td>
<td>Minis, workstations</td>
</tr>
<tr>
<td>OMC</td>
<td>1984</td>
<td>24.25</td>
<td>IMSI, Silicon Graphics</td>
<td>CAD/CAM, workstations, micros, data processing solutions</td>
</tr>
<tr>
<td>PSI</td>
<td>1976</td>
<td>18.7</td>
<td>Bull SA</td>
<td>Micros, minis, mainframes, software exports</td>
</tr>
<tr>
<td>TELCO</td>
<td>1985</td>
<td>4.64</td>
<td>—</td>
<td>CASE Tools</td>
</tr>
<tr>
<td>(Computer Div.)</td>
<td></td>
<td></td>
<td></td>
<td>Process control systems</td>
</tr>
<tr>
<td>TATA Honeywell</td>
<td>1984</td>
<td>61.0</td>
<td>Honeywell</td>
<td>Minis, superminis</td>
</tr>
<tr>
<td>Nelco</td>
<td>1990</td>
<td>190.0*</td>
<td>HW Italy, Bull, Memotec Data</td>
<td></td>
</tr>
</tbody>
</table>

* Computer division's turnover not available.
Despite its reputation, the Tata group is having difficulty adjusting to the IT industry's pulse. In IT, unlike steel, technology changes so rapidly that continuous and close monitoring is required, and new products have to be developed and marketed in quick response. IBM had to restructure itself and created 13 Baby Blues to focus on different market segments. Likewise, the Tatas are expected to delegate more decision-making powers to the companies within their focused market segments, and to build more collaboration and synergy among them. TISL, for example, can become systems integrator for banking solutions. For software services export, TCS can coordinate with others like TUL.

Companies may have to move from computer manufacturing, where economies of scale matter, to software and systems integration; already hardware revenues are dropping and software has become a major growth area for some Tatas, reflecting a trend of the global IT industry. As computerization in the banking sector and other key segments of the domestic market takes off, low performing ventures such as NELCO may reverse its performance.

As domestic end-users are freed to source IT globally, the Tatas should seek to excel in defining and delivering IT "solutions" to the Indian industry. They also need to invest more in solution packaging and marketing. They must become agile and strategically exploit their strengths as they compete in an increasingly competitive and exciting domestic market as well as abroad.

Source: Adapted from Dataquest (India), January 1994, pp.116-127.

India's policies and institutions may therefore be geared toward:

(a) Allowing access to a highly competitive supply of information technologies at costs as low as possible.

(b) Increasing the supply of complementary inputs (such as software and support services) essential for the diffusion and effective use of IT in the economy.

(c) Allowing hardware imported by free trade zones to be utilized for the domestic industry provided export commitments have been met.

Telecommunications and Data Communications

Telecommunications is a key part of the informatics sector. It is driven by advances in software and microelectronics, and in turn, it enhances the benefits and helps diffuse information and information systems. India has extremely low availability of telecom services, less than what most competing countries had over a decade ago (0.45 telephone lines per 100 inhabitant for India in 1987, compared with 0.59 for Thailand, 1.76 for Malaysia, and 3.32 for Mexico in 1977). In addition to the high (and unmet) demand for plain "old" telephone services,

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30This paper does not focus on Telecommunications as a key infrastructure in its own right. For full treatment of this element of informatics, see "India, The Telecommunications Sector: Policy, Performance, Technology and Manufacturing Capability", World Bank, 1992.
Mexico in 1977). In addition to the high (and unmet) demand for plain "old" telephone services, there is growing demand for many specialized and intelligent services to enable companies (and government agencies) to transfer data. Vital data communication services are impeded by the high cost of leased circuits, restrictive regulations, and poor quality local access circuits.

Although measures of demand for data communications at the national level are unavailable, and international experience suggests that projections typically underestimate the growing demand by wide margins, there are many indicators of the current gap and potential demand for advanced data communication services in India. Inter-bank payments, as well as payments and transactions within and among industries are excessively slow and payment services based on electronic data interchange (EDI) capabilities are altogether lacking. Such capabilities are also needed to transfer inventory and order-related data among manufacturers, distributors and retailers. In India, lack of such services has been a major contributor to excessive inventory and inability of local enterprises to adopt just-in-time and lean production practices, and thus to engage in international subcontracting. The high cost and poor quality of on-line interaction between software services providers and domestic and foreign users reduce the opportunities for expanding the domestic market and for entering into higher value-added software and information services for export. Data transaction capability constraints have also contributed to the slow and inefficient logistics systems within India, for ordering, invoicing and movement of goods.

The setup for data communications in India is rudimentary. Among the large public networks are NICNET and INDONET. NICNET is run by the National Informatics Center (NIC) with its own nationwide satellite-based network serving primarily government agencies in 450 cities. INDONET, run by CMC Limited, uses leased lines from the Department of Telecommunications (DOT) and is operated mainly for computer time leasing. Table 5 indicate the various network projects running or on the threshold of being commissioned, each with limited number of nodes, users, services and capabilities.

These services suffer from overloading, poor performance, and high cost. DOT has plans for commissioning a satellite-based network similar to NICNET using the same earth-station technology but without the value-added services that NIC provides. Four or five more networks are planned and may become available in the near future, which would introduce data communication at 64 kbps. As a result of present inadequacies, large corporate users, mostly in the public sector, are setting up private networks. But these have proved to be costly, as they depend on the inefficient and inadequate terrestrial voice communication network of DOT.
India faces a dilemma in seeking to fill the gap between supply and demand for telecom services, including the more advanced data and value added services. As new telephone connections have been provided, waiting lists, rather than shrinking, have grown dramatically. Currently, about 2.8 million applicants have registered their demand, and the demand is increasing at a rate over 20% annually. Almost 85% of all the villages (which number over half a million) do not have a single telephone. Yet, there is a growing and pressing demand from business for many specialized and intelligent services. This demand for data and business-support services cannot await meeting the demand for basic telephone service as such business services have become essential to modern manufacturing and service firms in an increasingly open economy. A dual structure therefore appears inevitable whereby specialized networks and advanced data services must be forged ahead and developed for business needs, perhaps for technology enclaves such as the Bangalore area, software parks, and Bombay's financial and trade services. Meantime, the goal of universal service and other social objectives cannot be neglected, and specific policies and programs for rural telecommunications and basic services should remain part of the overall telecommunication reform package.

**TABLE 5: Data Networks in India**

<table>
<thead>
<tr>
<th>S/No.</th>
<th>Network</th>
<th>Provider</th>
<th>Objective</th>
<th>Medium</th>
<th>Services</th>
<th>No. of Users</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>RABMN</td>
<td>DoT</td>
<td>Satcom for remove users</td>
<td>Satellite</td>
<td>Messaging</td>
<td>300</td>
</tr>
<tr>
<td>2.</td>
<td>INDONET</td>
<td>CMC</td>
<td>Info. tech for all in India</td>
<td>Terrestrial Transfer, Databases</td>
<td>E-Mail, File</td>
<td>600</td>
</tr>
<tr>
<td>3.</td>
<td>I-NET</td>
<td>DoT</td>
<td>Reliable datacomm Packet switched</td>
<td>Terrestrial Transfer, Databases</td>
<td>E-Mail, File</td>
<td>1200</td>
</tr>
<tr>
<td>4.</td>
<td>GPSS</td>
<td>VSNL</td>
<td>Overseas datacomm</td>
<td>Satellite Transfer, Databases</td>
<td>E-Mail, File</td>
<td>630 Locations</td>
</tr>
<tr>
<td>5.</td>
<td>NICNET</td>
<td>NIC</td>
<td>MIS n/w for Gol</td>
<td>Satellite</td>
<td>E-Mail, File Transfer</td>
<td>450 districts</td>
</tr>
<tr>
<td>6.</td>
<td>ERNET</td>
<td>DoE</td>
<td>Datacomm for Edn and R&amp;D</td>
<td>Satellite + land Transfer, Databases</td>
<td>E-Mail, File</td>
<td>85</td>
</tr>
<tr>
<td>7.</td>
<td>BANKNET (on INDONET)</td>
<td>RBI</td>
<td>N/w for interbank Communication</td>
<td>Terrestrial</td>
<td>File Transfer</td>
<td>254 locations</td>
</tr>
<tr>
<td>8.</td>
<td>SAILNET (on NICNET)</td>
<td>SAIL</td>
<td>Communication needs of SAIL</td>
<td>Satellite + Land</td>
<td>File Transfer</td>
<td>Major SAIL Sites</td>
</tr>
<tr>
<td>9.</td>
<td>OILCOMNET</td>
<td>OCC</td>
<td>Communication needs of Oil sector</td>
<td>Satellite + Land</td>
<td>Messaging</td>
<td>Major Oil centers</td>
</tr>
<tr>
<td>10.</td>
<td>SOFTNET</td>
<td>DoE</td>
<td>Promotion of S/W Exports</td>
<td>Satellite</td>
<td>All types</td>
<td>NA</td>
</tr>
<tr>
<td>11.</td>
<td>ICNET</td>
<td>ICNET</td>
<td>Value Added Services</td>
<td>Terrestrial for all sectors</td>
<td>E-Mail, Databases</td>
<td>25 locations</td>
</tr>
</tbody>
</table>

Source: NASSCOM
Recently, there has been growing support for reforms to enhance telecommunication services as a way of supporting the momentum of the overall economic reform program. The Athreya Committee and the Telecommunication Commission are examining options for encouraging private investment in telecommunications, and for allowing DOT greater autonomy and flexibility.

Progress in this area would increase competition and create the policy framework for competitors to provide more responsive data communication services. In addition, software and information services could benefit from high-speed on-line interaction with domestic and foreign users. A fundamental requirement to sustainable progress is to allow greater degree of private sector involvement in the provision of services. This could occur for specific services, such as data transmission networks, and in the form of overlay networks. Public-private partnerships are both possible and necessary in India in this area. Progress in this area would open major opportunities for off-shore software services activities in India, thereby reducing dependence on body-shopping (on-site delivery of services) and the consequent brain-drain. The use of improved, high-speed data communications might also save foreign exchange by enabling Indian software firm to access electronically most advanced and expensive hardware platforms and software tools that reside at the user or contractor facility. The presence of advanced data communication would also open up new areas of software export such as software maintenance.

Software Services

The Indian software industry, although small by industrial country standards, has been growing at an exceptional compound annual rate of 21 percent between 1987 and 1991 in total, and 35 percent for exports. This growth is considerably faster than the 15 percent rate in the United States during the 1984-87 boom period. However, when compared to the total industry performance of other competitor countries, India appears to be behind all of these countries except Israel (Table 6).

Marketed software is the visible (and probably smaller) component of the overall demand for software goods and services. Trade data understate the level and composition of demand for software in at least three ways. First, many of the larger public and private user organizations have electronic data processing (EDP) and management information systems (MIS) departments that provide in-house and government software services. Second, a proportion of software sales is still bundled with investments in large computer systems, without separate prices defined for software systems, training, and maintenance. Third, since the shift from mainframe to personal computers, there has been more software piracy.
Table 6 - Comparison of India's Software Industry with Competitors

<table>
<thead>
<tr>
<th>COUNTRY</th>
<th>INDIA</th>
<th>IRELAND</th>
<th>SINGAPORE</th>
<th>ISRAEL</th>
<th>CHINA (PRC)</th>
<th>PHILIPPINES</th>
<th>MEXICO</th>
<th>HUNGARY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1990 CAGR %</td>
<td>1990 CAGR %</td>
<td>1990 CAGR %</td>
<td>1990 CAGR %</td>
<td>1990 CAGR %</td>
<td>1990 CAGR %</td>
<td>1990 CAGR %</td>
<td>1990 CAGR %</td>
</tr>
<tr>
<td>Total Industry</td>
<td>4%</td>
<td>20%</td>
<td>28%</td>
<td>15%</td>
<td>5%</td>
<td>19%</td>
<td>25%</td>
<td>46%</td>
</tr>
<tr>
<td>Domestic</td>
<td>113</td>
<td>154</td>
<td>154</td>
<td>28%</td>
<td>25%</td>
<td>5%</td>
<td>19%</td>
<td>20%</td>
</tr>
<tr>
<td>Imports</td>
<td>30</td>
<td>40</td>
<td>105</td>
<td>22%</td>
<td>5%</td>
<td>11%</td>
<td>20%</td>
<td>30%</td>
</tr>
<tr>
<td>Exports</td>
<td>120</td>
<td>185</td>
<td>89</td>
<td>43%</td>
<td>16%</td>
<td>43%</td>
<td>32%</td>
<td>30%</td>
</tr>
<tr>
<td>Total</td>
<td>271</td>
<td>379</td>
<td>348</td>
<td>30%</td>
<td>26%</td>
<td>31%</td>
<td>201</td>
<td>23%</td>
</tr>
<tr>
<td>Domestic Market**</td>
<td>4%</td>
<td>20%</td>
<td>36%</td>
<td>30%</td>
<td>44%</td>
<td>65%</td>
<td>55%</td>
<td>72%</td>
</tr>
<tr>
<td>- Packaged Software</td>
<td>5</td>
<td>154</td>
<td>154</td>
<td>28%</td>
<td>25%</td>
<td>3%</td>
<td>23%</td>
<td>25%</td>
</tr>
<tr>
<td>- Professional Services</td>
<td>105</td>
<td>154</td>
<td>154</td>
<td>28%</td>
<td>15%</td>
<td>2%</td>
<td>15%</td>
<td>20%</td>
</tr>
<tr>
<td>Total</td>
<td>115</td>
<td>379</td>
<td>348</td>
<td>30%</td>
<td>26%</td>
<td>31%</td>
<td>201</td>
<td>23%</td>
</tr>
<tr>
<td>% of Total Industry</td>
<td>42%</td>
<td>41%</td>
<td>44%</td>
<td>65%</td>
<td>18%</td>
<td>55%</td>
<td>72%</td>
<td>72%</td>
</tr>
<tr>
<td>Import Market</td>
<td>4%</td>
<td>20%</td>
<td>36%</td>
<td>30%</td>
<td>44%</td>
<td>65%</td>
<td>55%</td>
<td>72%</td>
</tr>
<tr>
<td>- Packaged Software</td>
<td>36</td>
<td>105</td>
<td>105</td>
<td>22%</td>
<td>5%</td>
<td>11%</td>
<td>20%</td>
<td>30%</td>
</tr>
<tr>
<td>- Professional Services</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>36</td>
<td>105</td>
<td>105</td>
<td>22%</td>
<td>5%</td>
<td>11%</td>
<td>20%</td>
<td>30%</td>
</tr>
<tr>
<td>% of Total Industry</td>
<td>14%</td>
<td>11%</td>
<td>30%</td>
<td>14%</td>
<td>18%</td>
<td>20%</td>
<td>24%</td>
<td>8%</td>
</tr>
<tr>
<td>Export Market</td>
<td>3%</td>
<td>20%</td>
<td>36%</td>
<td>30%</td>
<td>44%</td>
<td>65%</td>
<td>55%</td>
<td>72%</td>
</tr>
<tr>
<td>- Packaged Software</td>
<td>6</td>
<td>53</td>
<td>53</td>
<td>49%</td>
<td>42%</td>
<td>10%</td>
<td>42%</td>
<td>24%</td>
</tr>
<tr>
<td>- Professional Services</td>
<td>106</td>
<td>120</td>
<td>120</td>
<td>41%</td>
<td>35%</td>
<td>3%</td>
<td>50%</td>
<td>35%</td>
</tr>
<tr>
<td>- Supp Svs (Data Entry)</td>
<td>2</td>
<td>20</td>
<td>20</td>
<td>25%</td>
<td>3%</td>
<td>35%</td>
<td>20%</td>
<td>20%</td>
</tr>
<tr>
<td>- Supp Svs (Doc., Conv.)</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>45%</td>
<td>42%</td>
<td>1%</td>
<td>45%</td>
<td>0.1%</td>
</tr>
<tr>
<td>Total</td>
<td>120</td>
<td>185</td>
<td>89</td>
<td>43%</td>
<td>18%</td>
<td>43%</td>
<td>51</td>
<td>32%</td>
</tr>
<tr>
<td>% of Total Industry</td>
<td>44%</td>
<td>49%</td>
<td>26%</td>
<td>21%</td>
<td>64%</td>
<td>25%</td>
<td>15%</td>
<td>20%</td>
</tr>
</tbody>
</table>

*Cumulative Average Growth Rate
Source: IDC and InfoTech, World Bank-financed study, 1992
Figure 2: Vertical Specialization of Indian Software Companies

<table>
<thead>
<tr>
<th>Sectors</th>
<th>Number of Companies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Banking</td>
<td>67</td>
</tr>
<tr>
<td>Insurance</td>
<td>42</td>
</tr>
<tr>
<td>Defense</td>
<td>7</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>54</td>
</tr>
<tr>
<td>Hotels</td>
<td>14</td>
</tr>
<tr>
<td>Transport</td>
<td>23</td>
</tr>
<tr>
<td>Health</td>
<td>19</td>
</tr>
<tr>
<td>Communication</td>
<td>38</td>
</tr>
<tr>
<td>Government</td>
<td>40</td>
</tr>
<tr>
<td>Others</td>
<td>40</td>
</tr>
</tbody>
</table>

Source: NASSCOM.
Indian software is in many respects still an "infant." Except for a few large firms that have become established as industry leaders, it consists of mostly small firms at a relatively early stage of professional organization. The business know-how and computer expertise of the Tata Group--Tata Consultancy Services (TCS) and Tata Unisys Ltd. (TUL)--and CMC, a public enterprise, have greatly contributed to early efforts to build the software industry.

Many small companies have entered the market in the past three years in part because of export prospects and growing modernization needs as well as the relatively low barriers to initial entry in terms of capital requirements. Depending on the type of operation -- for example, renting out programmers abroad--some firms operate with a one-room office, telephone and fax. Over three-fourths of the companies have fewer than 25 professionals. The structure of the sector is highly concentrated, with the top three vendors each selling more than US$10 million in software services and products. Approximately 95 percent of firms had software revenues of under US$100,000 (per firm). A growing number of companies have exceeded $1 million in sales: from 15 companies in 1990 to 44 in 1992; and 27 of them have exported over $1 million each in 1992. Table 7 indicates the top fifteen exporters (who account for about 64 percent of total software exports) and the top fifteen players in the domestic market (who account for 37 percent of total domestic software revenues). Figure 2 shows the growing specialization and sectoral coverage of India’s software industry.

A structural problem: the export growth has come mainly from the provision of contract programmers to carry out low-level work ("body-shopping" or "manpower contracts" in which the overseas buyer typically buys "hours" and not a total project or product with the associated management and high-value added technical services). Indian firms undertake mostly the routine tasks of coding and debugging--rather than higher skill tasks of design, analysis, and project management. These contracts are generally short in term, low in risk, low in value added, and low in investment, but they represent 70-80 percent of the industry’s export revenues. Typically, programmers are contracted out to work for a client at an agreed hourly or monthly rate for six to eighteen months. They perform data conversion or coding jobs, such as conversion from batch-processing to on-line systems or conversion from source code to UNIX-based systems. This has several undesirable aspects:

- Body-shopping is often an on-site service--once the personnel are abroad, the temptations to remain abroad are strong. One of the main spinoffs of export work--expanding the domestic knowledge pool--is thus defeated. And the costs of endlessly training new personnel must be added to low profit margins, though exact figures on these costs are not available.

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31Annex 2 discusses some government policies and initiatives to expand India’s software industry.
Table 7. Top Software Exporters and Domestic Players

<table>
<thead>
<tr>
<th>Rank</th>
<th>Company</th>
<th>Domestic (Rs million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Tata Consultancy Services</td>
<td>410.00</td>
</tr>
<tr>
<td>2.</td>
<td>CMC Limited</td>
<td>269.90</td>
</tr>
<tr>
<td>3.</td>
<td>Tata Unisys Limited</td>
<td>134.00</td>
</tr>
<tr>
<td>4.</td>
<td>Onward Computer Technologies</td>
<td>94.40</td>
</tr>
<tr>
<td>5.</td>
<td>Sonata Software</td>
<td>93.90</td>
</tr>
<tr>
<td>6.</td>
<td>Pertech Computers Limited</td>
<td>84.70</td>
</tr>
<tr>
<td>7.</td>
<td>NIIT Limited</td>
<td>81.00</td>
</tr>
<tr>
<td>8.</td>
<td>Wipro Systems Limited</td>
<td>80.80</td>
</tr>
<tr>
<td>9.</td>
<td>Citicorp Information Technology Ind. Ltd.</td>
<td>77.70</td>
</tr>
<tr>
<td>10.</td>
<td>Tata Elxsi Limited</td>
<td>74.50</td>
</tr>
<tr>
<td>11.</td>
<td>ITC Limited</td>
<td>73.10</td>
</tr>
<tr>
<td>12.</td>
<td>Mastek Limited</td>
<td>72.50</td>
</tr>
<tr>
<td>13.</td>
<td>Rolta India Limited</td>
<td>72.00</td>
</tr>
<tr>
<td>14.</td>
<td>Mafatlal Consultancy Services</td>
<td>70.30</td>
</tr>
<tr>
<td>15.</td>
<td>M.N. Dastur &amp; Co.</td>
<td>52.00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rank</th>
<th>Company</th>
<th>Exports (Rs million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Tata Consultancy Services</td>
<td>1754.80</td>
</tr>
<tr>
<td>2.</td>
<td>Tata Unisys Limited</td>
<td>560.00</td>
</tr>
<tr>
<td>3.</td>
<td>Digital Equipment (India) Limited</td>
<td>317.80</td>
</tr>
<tr>
<td>4.</td>
<td>Citicorp Overseas Software Limited</td>
<td>209.40</td>
</tr>
<tr>
<td>5.</td>
<td>Wipro Systems Limited</td>
<td>172.00</td>
</tr>
<tr>
<td>6.</td>
<td>Siemens Information Systems Limited</td>
<td>160.00</td>
</tr>
<tr>
<td>7.</td>
<td>PSI Data Systems Limited</td>
<td>156.50</td>
</tr>
<tr>
<td>8.</td>
<td>Patni Computer Systems</td>
<td>156.20</td>
</tr>
<tr>
<td>9.</td>
<td>Reesan Information Management Res.</td>
<td>148.50</td>
</tr>
<tr>
<td>10.</td>
<td>ICIM Limited</td>
<td>130.00</td>
</tr>
<tr>
<td>11.</td>
<td>Texas Instruments</td>
<td>128.40</td>
</tr>
<tr>
<td>12.</td>
<td>Infosys Technologies Limited</td>
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<td>13.</td>
<td>Mahindra British Telecom Limited</td>
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<td>14.</td>
<td>Silverline Industries Limited</td>
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<td>15.</td>
<td>Index Computing Pvt. Limited</td>
<td>82.80</td>
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Source: NASSCOM
Even those who do return have gained little or no experience of larger scale project management, exacerbating the situation caused by the comparative dearth of large domestic projects.

There is a low perception of Indian software skills in OECD markets, particularly in project management, the ability to complete projects on time, and the responsiveness to changes to specifications.\textsuperscript{32}

Demand for these skills is likely to be eroded by tools that automate many of these tasks. Further, many developing countries such as China and Eastern European countries are entering this low end of the industry and undercutting Indian prices.

Globally, a long-term decline in demand for routine or low-level programmers has been forecasted. A rise in demand for higher-level computer, software, and communication expertise is expected. This means that rather than programmers, the software industry will need well-educated systems development managers and project leaders, electronic and communications engineers and technicians, software engineers and technicians. These trends lessen the competitiveness of less skilled exporters. Indian firms will find it considerably harder to gain market entry overseas and sustain their position without either strategically linking to resident firms in, say, the United States, or offering products and services of competitive value.

A survey of 150 U.S. and European hardware and software manufacturers has ranked India vis-a-vis competitors on important criteria with respect to exporting systems development and programming services.\textsuperscript{33} Accordingly, Indian software services enjoy the lowest labor cost after China, has one of the largest pools of labor supply, and has the

\textsuperscript{32} ODA, "Report on Common Research into the European IT Market Carried Out as part of the DECTA Software Project," London, July 1991, Part II, "General Attitudes to Indian Developers."

Figure 3: Competitive Analysis of Software Services

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<th>India</th>
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Weakness: Below parity | Parity | Above parity | Strength

advantage of English speaking. But, compared with competitors, India has the disadvantages of poor telecommunications infrastructure, and is not above parity regarding the availability of specialized education and training and several other criteria. Moreover, it has yet to exploit the "potential" competitive advantage of a large domestic market that could help in acquiring experience in higher value-added segments of software services and in tapping foreign expertise through joint-ventures and direct foreign investment.

Constraints on the Software Industry

The software industry has been constrained by: (a) an underdeveloped domestic market (paras 3.26-3.29); (b) weak marketing (paras 3.30-3.31); (c) the inadequacy of finance mechanisms (para 3.32); (d) the inadequacy of data communication infrastructure (paras 3.12 to 3.18); (e) the shortage of high quality software engineering education and training (paras 4.30 to 4.42); (f) policies concerning public procurement of software and software services, import restrictions on hardware and software, and legal protection for software (paras 3.33-3.36 and 4.6-4.15). Any strategy to accelerate India's informatics sector and optimize the sector's performance will have to address these issues.

In any country, the domestic informatics market is an important base for developing the expertise and experience needed to compete in the international marketplace. As seen in Table 1, performance in the domestic market for Indian software appears below that of all other competitor countries with the exception of the Philippines. The domestic market for software in India amounted to about US$113 million in 1990, with India ranking next to last among eight other countries (Figure 4).

Developing the software industry requires absorbing new technologies for software production, monitoring and analyzing trends in the industry, and using software to solve domestic productivity problems. And the cost of developing such capabilities increases rapidly over time. So, the lack of a large and strong domestic base will hinder the growth of software exports, since such exports depend increasingly on a proven "track record" and experience in developing large and complex systems in domestic projects.

The limited access to up-to-date hardware and software engineering tools, as well as the absence of adequate domestic and international communications facilities, has already forced companies to send Indian software developers to work on their clients' premises overseas rather than in India. Larger system platforms (such as IBM mainframes) are generally unavailable, as are telecommunications earth stations with capacity to support software exports and continuous interaction between client and developer. That is probably why software developers and managers, who tend to be five years behind in their experience and familiarity with technology, have been slow to react to global technological and management

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Figure 4: Growth Rates – Domestic Market

Compound annual growth rate (%) as of 1990

trends (CASE tools, 4GLS, window environments, graphical user interfaces) and to adopt well-known software standards and quality assurance procedures.\textsuperscript{35}

In several sectors--energy, railroad management, water management, power generation, and electronics--public enterprises, institutes of higher education, and a few private firms have designed, developed, installed, and maintained either large computer-based information systems or software packages. And some large companies are beginning to do R&D in software for plant control, process design, and manufacturing automation. The Computer and Management Centers (established in 1983 in the Indian Institutes of Management) have been developing computer applications for government and public enterprises in transport, energy, and district planning. The National Informatics Center (NIC) has developed some 100 software packages for high volume transactions, district planning, and CAD-CAM. But the focus on promoting software exports for foreign exchange has eclipsed efforts to expand domestic software development projects.

Another key constraint is marketing.\textsuperscript{36} There is an urgent need to strengthen both the capabilities of firms to design and implement marketing programs and to have greater access to international expertise and information in marketing software and related services. Budgets tend, moreover, to be low: few package producers devote anything like the 70 to 80 percent of revenue that global package producers typically allocate to marketing. Nor is there much strategic marketing, with many software companies relying on "word of mouth." And because of difficulties in obtaining foreign exchange and other restrictions on the use of foreign exchange earned by software exporters, funding export marketing has been difficult--reducing knowledge of target markets and undermining the already limited marketing efforts. Most firms, especially small ones, lack information about the technical and market requirements overseas, and poor market information often leads to development of the wrong products and waste of scarce capital.

Much multilateral and bilateral assistance has been for unduly generic market research--or for unduly isolated efforts (subsidizing country visits, and trade show exhibits, hoping to find sales agents). Generic market research, often too general for any individual company to make business decisions, may be complemented by working with selected companies one-to-one.

\textsuperscript{35}It is estimated that 50,000 to 70,000 CASE products have been installed in the United States, compared to approximately 200 in India. Edward Yourdon, \textit{Decline & Fall of the American Programmer}, Englewood Cliffs, NJ, Yourdon Press/Prentice Hall, 1992. The import duty of 107 percent on CASE products makes it uneconomic to purchase CASE products, thus contributing to the lack of automated support and the low levels of productivity among software professionals.

Small software firms, the majority, have found it particularly difficult to obtain finance. First, long-term funding—even by the innovative venture capital funds such as TDICI and RCTFC—has been geared largely to cover assets, with lenders tending to advance loans only against the security of fixed assets. Software companies typically have low fixed asset bases, relying instead on human skills and intellectual property. Moreover, "sweat" equity (the equity value of a promoter's organizing efforts, ideas, and knowledge) is not yet recognized in India, and there is thus no practical "exit route" for venture capitalists. Second, lenders of funds for working capital (the commercial banks) have strict norms of lending only against the collateral of raw material stocks, work in progress, and finished goods. Third, some venture capital companies also have minimum investment limits that do not allow them to invest in small software companies. Fourth, although recent regulatory changes have made it easier to raise public funds, most software companies are too small (in paid-up capital) to mount public offerings. Fifth, the rapid expansion of software companies (40 percent annually) presents expansion risks unfamiliar to financial institutions in India, and further increases the need for working capital.

Another hindrance to the domestic software industry was the government policy to give CMC, a state enterprise, a legal monopoly to service computer systems not manufactured in India, and to execute software development and service projects for public agencies. This policy, in effect for nearly 15 years beginning in 1975, discouraged private companies from looking to the public sector for sales and experience in large systems projects. Although CMC has no longer a monopoly on servicing the public sector, it still enjoys preferential access. Meantime, its current status as a public department has become a major constraint to its potential to be an internationally-competitive "systems integrator."

Yet another hindrance has been the National Informatics Center (NIC), an autonomous body serving the information technology needs of the Government public sector corporations. NIC has been designing informatics projects, developing a wide range of database applications, and operating a satellite-based data network (NICNET) for the past six years or so. It has also been experimenting with programs to bring the benefits of information technology to rural areas. All salutary, but the activities of NIC have created barriers to entry (to the government services market) for independent software houses.

The policy environment for hardware, which attempted a high degree of self-sufficiency, has resulted in much of the latest hardware in the world being unavailable at affordable prices in India. For example, Indian software companies typically have little

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The problem is not confined to India. Most small firms in OECD countries have found difficulties in obtaining finance. In Holland, for example, the government has stepped in to fulfill the role of a bank, lending to small software firms to do R&D. Evaluation of this policy by the OECD has found it to be largely successful, with some firms now exporting.

Venture capital currently represents less than 1 percent of the sources of funding for software companies compared with over 30 percent in the United States. Indian venture capital companies are new and lack the industry and technical knowledge required to properly assess software markets and products or the merits of professional software firms.
mainframe exposure, particularly in large mainframe software markets (e.g., IBM). This significantly reduces export opportunities for Indian software companies with large end-user organizations, systems vendors, and large professional services firms.

Other local practices have also led to under-developed domestic markets. Software piracy discourages investment in software package development and local market development. Managers of information systems (MIS) departments prefer in-house development of software over outsourcing such services from the domestic market. The poor integration of information technology management with business strategy and management perpetuates the existence of large centralized and isolated MIS departments, with no incentive to downsize, outsource, or seek enhanced services. And, for a variety of reasons, Indian users remain reluctant to pay for software. But, despite these constraints, the domestic market for software has grown by 39% for software services and by 35% for package software, between 1991-92.
IV. POLICIES, INSTITUTIONS, AND CAPABILITIES

Policies

The primary objective of public policy for information technology in any developing country should be to exploit the potential of the technology to serve the whole economy. Translating the potential of IT use into effective demand implies open and competitive markets for IT hardware. This objective must be reconciled with India's aspirations to enhance its capabilities in producing all types of hardware, computers, and telecommunications equipment.

In India, policies concerning the information technology industry have been shaped by her overall industrial and technology strategy, which emphasized the development of scientific, technological and industrial capabilities. This strategy had mixed results, with the costs of inefficiency and slow application and diffusion of information technology outweighing the benefits of technological deepening. With the exception of the software services, state enterprises have dominated the strategic or high-tech areas of the electronics sector, while private consumer electronics firms remained domestically oriented. In terms of structure of the electronics sector, India has one of the highest ratios of production in the consumer electronics and the lowest in electronics data processing and in components among the newly industrializing economies. On the other hand, it has built a diversified sector and broad technological capabilities. However, the impressive technological achievements, particularly in the local production of computer and telecommunications equipments, and in the development of an extensive science and technology infrastructure, did not lead to fully competitive production or to wide use of these capabilities by user industries and services.

Recognizing that information technology (and electronics, in general) is a source of productivity improvement for the industrial and services sector, the government has singled out electronics for a series of policy reforms since 1985. This included gradual liberalization of the restrictions on entry and exit, more flexibility to adjust both output mix and capacity in those sectors still subject to licensing, virtual elimination of the policy of reserving some products for small-scale industry, and access to imported goods assured through an open general license category. Since then, quantitative restrictions have been greatly reduced and import duty structure has been rationalized. More recently, since 1991, substantial reforms in trade and industrial policies have had significant impact on the orientation and competitiveness of the electronics sector. Many of these reforms have been particularly relevant to the software segment of this industry, which has been driven by a strong export-orientation. While the electronics industry as a whole exported less than 6% of total production in 1991, the export of software is about 55%. A distinct change in the policy environment has also led to the recent interest of major IT multinationals to invest in India. Perhaps one of the most dramatic signal is the return of IBM for a joint venture with Tata Industries.

Trade policies have recently put a high priority on the export of software services, with success. The government has extended a number of export incentives to the software
industry such as 100% tax exemption on export profits, free-trade zones and software technology parks, and progressive decline in duty for the import of hardware. These policies have led to a virtual boom in software exports, which presently account for about 55 percent of total software industry turnover.

Further liberalization of imports and reduced tariffs are likely to enhance access to large computer systems and various microelectronics-based products. Major restrictions remain on the import of computers with a CIF value below $20,000. Customs duty on imported computers, electronic components, software, computer peripherals, and telecom and data communication equipment still average 110 percent (ranging from 95 to 145 percent). These restrictions and additional costs naturally reduce access to the advanced technology platforms and productivity tools needed for an internationally competitive software industry--and for diffusing IT throughout the economy.

Public procurement policies and practices for computers and information systems are also deficient—in four ways. First, despite recent policy changes that eliminated procurement preferences for public agencies, current informal practices still favor two large public agencies, CMC and NIC. Many complex systems projects were given to CMC because of its special competencies in systems integration. But limits on competition in public procurement—and the unwillingness of large software companies to subcontract specialized or low-skill activities to small software houses—have retarded the private software industry and the domestic market for software services. Moreover, public sector companies have large data processing (EDP) departments, which favor in-house software development, rather than outsourcing such services. The experience of industrial countries, as well as the private sector in India suggests that effective outsourcing often result in lower cost, timely delivery, and more advanced systems solutions. Moreover, outsourcing large public systems development projects also provides the local software industry with significant opportunities to develop software packages for the public sector at large, and subsequently, for export.

Second, public procurement practices tend to bundle hardware with software and to undervalue the software, training, consultancy, and support services associated with IT procurement. In response, hardware vendors underprice the software and hide its cost in the hardware price, gaining unfair marketing advantage and constraining the development of a competitive domestic market for software and related services. This situation appears to be changing. Guidelines for public sector agencies and enterprises may be further developed to ensure appropriate budgeting and procurement for information systems particularly software and training.

Third, public procurement practices suffer from poor planning and analysis of information and communication requirements. This leads to costly mis-specifications and modifications, unnecessary over-investment and mis-allocation of hardware capacity, and poor

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39With the recent steep devaluation of rupee, the cost of imported software for local users may have increased by another 50 percent.
communication between systems and applications. Most tender documents, biased toward highly technical specifications of hardware, do not clearly identify functional objectives and benefits, reducing competition and the ability to address information problems. Also ignored are needed organizational adjustments and complementary inputs, such as training and implementation support, as well as needed redesigns of work processes and management structures, where the strategic benefits from IT are most likely to occur.

Fourth, the public sector has not used its substantial IT investments to promote technical standardization or the migration toward "open" systems standards. Such standardization would facilitate information sharing, reduce training and support requirements, enhance compatibility and inter-operability, and increase returns on investment in information systems in public agencies. It would also reduce the information problems that face both vendors and public procurement officers.

The management and dissemination of public information have few policies or standards. Formal regulations and practices tend to encourage secrecy and restrict information-sharing among public agencies and with the private sector. For example, there are few standards and weak incentives for data quality. Despite substantial investments in data collection and statistical offices, there are no incentives to encourage the use and dissemination of such data. Most information is collected and stored in paper, severely reducing its value for other public agencies and for private intermediaries. Nor is there a public policy for sharing data or for coordinating database investments in the public sector. Data standards, formats, definitions, and mediums for storage differ among public agencies, generating substantial barriers to sharing. There is also substantial duplication in data collection and information systems within the same field or city.

Intellectual property rights is another issue facing the Indian software industry, for software piracy is serious. The Indian market abounds with pirated copies of software, especially for personal computers. The economic rationale for copyright protection has been less than apparent for most developing countries that are largely importers of information products. There are arguments in favor of weak protection, since foreign exchange savings, diffusion of computer applications among resource-constrained users, low-cost technology transfer, and rapid access to the international frontier for software technology are seen as benefits of weak copyright protection. But there are limits to these benefits. The declining marginal benefits from unauthorized copying has to be set against the increasing costs of an undeveloped local software industry. Developing software skills are critical to the effective use of IT—and to the potential for high value-added exports and employment. India may lose out on both. Moreover,

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*For example, the "Official Secrets Act" of 1923, still governs the sharing of public information.

*This issue should be put in perspective, as India is not a major offender when compared to many other developing and industrialized countries. According to the International Intellectual Property Alliance, India is the 12th ranked country on the global scene and the 6th in the Asia Pacific Region, as far as the level of losses to multinationals from software piracy.*
inadequate legal protection may threaten trade relations with the United States and deter foreign investment in the sector.

India needs to develop an intellectual property regime suited to its level of development and its aspirations to become a major global player in the area of software and related services. It should further amend the Copyright Act (1984) to curb software piracy. The DOE and NASSCOM are taking encouraging steps, and the public sector should set an example by allocating separate and adequate budgets for software acquisition. A strong defense against piracy is reasonably priced software, but today's high customs duty strengthens the incentives to pirate imported software. Provision of better support services by foreign and local software companies for the packages they develop (or represent) should also help in making legal copies more attractive. Finally, an intellectual property regime must be phased toward greater protection of rights in line with the growing competitiveness of the local software industry and local capacity for enforcement.

The legal framework for information security and privacy also needs further development to facilitate the growing use of electronic-based transactions and information sharing. In an administrative culture, records and transactions require signatures and counter signatures at several levels. Computerization raises new issues and concerns regarding security, accuracy and confidentiality, for example, preventing tampering with statements and records, designating responsibility for possible errors caused by a computer, retrieval of information by unauthorized persons, and so on. Experience so far in India indicates that privacy has not yet acquired much significance, except marginally in the case of bank accounts and personnel information systems. Indian software companies are also learning to build safeguards into systems design rather successfully, as in the case of the railways reservation system.

However, there is a growing concern that the existing rules may not be adequate for settling legal disputes. For instance, the Evidence Act, the Negotiable Instruments Act and the acts relating to archives and records may have to be updated and improved. It may even be necessary to formulate a new legal framework to provide protection against information abuses and illegal access to information. Such frameworks should also challenge organizations to develop ways to promote information quality, transparency and sharing. Modernization of the Indian economy through informatics thus requires investment in a complementary legal infrastructure.

While the recent policy changes are significant and in the right direction, more needs to be done to exploit the technological capabilities already developed, stimulate technology transfer and strategic partnership, and build the enabling policy and institutional environments for wide and effective application of the technology in key economic sectors.
Institutions

There is no single apex institution or focal point for formulating national policies and strategies for the IT sector, not surprising given the size and complexity of India's economy and the recent emergence of this sector. But the Secretary of the Department of Electronics (DOE), committed to defining the role of information technology in meeting national priorities, has indicated his strong interest in formulating a national IT plan—with World Bank assistance. The DOE has also created a national commission for the computer and software industries, with broad representation from public and private agencies. With some technical assistance, this commission may become a national focal point for formulating policies and programs to promote this strategic industry. The DOE also needs to build its capacity to analyze policy options, monitor and assess the implications of ongoing global trends, and create consensus and information sharing fora on national programs to promote the software industry and associated services.

The government—through the Department of Electronics (DOE), the Ministry of Commerce, and the NIC—and the industry associations—such as the National Association of Software and Services Companies (NASSCOM) and the Manufacturers' Association of Information Technology (MAIT)—have provided broad support for the IT sector (see Annex 4 for a description of the main institutions concerned with software industry). Both the DOE and the Ministry of Commerce now appear to be motivated mainly to support rather than control the IT industry. This change, especially for the DOE, is important for the development and export promotion of the electronics and software industries, as the process of market liberalization takes hold and private sector demand for specific informatics skills and services increases. As part of the Ministry of Commerce's export promotion strategy, it has identified a few sectors that could achieve at least 30 percent export growth annually over the next three years, including software.

In general, the institutional framework is underdeveloped for dealing with systemic problems of computer and software requirements, planning, procurement, coordination among agencies, and IT diffusion. The IT associations are still in an early phase of development. It is rare for diverse industry and government groups to exchange ideas, define needs and requirements, and reach consensus on mutually beneficial goals and objectives in the IT field. The software industry association, NASSCOM, was established in 1988 as a source of technical information, as a conduit for energizing the private IT industry, and as a mechanism for self-policing. But it needs to do much more.

Research and Technology Transfer. India has made substantial investments in R&D for the hardware industry, and has developed impressive technological competencies in some areas such as advanced computing. Among the R&D agencies dedicated to IT (electronics, computer hardware, etc.) are: the Center for Advanced Computing (C-DAC), the Center for Development of Telematics (C-DOT), Applied Microwave Electronics Engineering and Research (SAMEER), and the Electronics Research and Development Centers (ER&DCs). But, there are few research (or educational)
institutions to do systematic work on new programming techniques, local languages, character recognition, and the like—or to examine what needs to be done to advance software quality, promote best practices in information management and technology use, and address IT trends and implications for India. The heavy government involvement in research and in the selection of technology on behalf of industry is giving way to gradual transfers of R&D responsibility to the firms, increased emphasis on applied research, and research to complement rather than reinvent imported technology. The Industrial Technology Development Project is supporting this transition. But the structure of the software industry (mostly very small firms) suggests that special R&D programs and institutions are required to respond to industry and market needs.

The software industry is highly research intensive; the average US software company spends 15 percent of its sales on R&D while the average (much smaller) one in India is spending 3 percent. Much local R&D is devoted to voice recognition and image processing, which make software easier to use. Although the Indian Institute of Science (IISC) has one of the most advanced artificial intelligence centers in developing countries, it has few links or joint projects with local software companies. Most companies develop technologies internally, if at all. With few exceptions, software companies also have difficulty tracking trends and changes in software and hardware technologies developed abroad. Research institutions—typically more interested in technology development than technology capture or making existing technology work for India—are of little help.

A few but growing number of Indian software firms possess some advanced technical capabilities that rival international competitors. But so far technology transfer from the large and dominant software houses to the small and medium software firms has been limited—due to the unwillingness of these large firms to subcontract to other software houses. This has discouraged specialization in software technologies and applications. Nor are large hardware firms willing to subcontract software design to the relatively smaller software companies. Large users and suppliers of IT are not organized (in consortia) to advance technological capabilities in line with domestic priorities. The practice of creating ancillaries, common in other industries, is practically nonexistent in the software sector.43

The benefits of increased links between large and small software houses could be substantial. Consider the adoption of Computer-Aided Software Engineering (CASE). A large Indian software company is marketing a CASE package in the United States. This package was developed locally. It allows for substantial increases in the productivity of software engineers. Yet, the adoption of CASE tools in India is meager. Developments in CASE and its increased use by U.S. software companies are likely to increase the productivity (and quality) gap between U.S. and Indian software engineers, undermining India's current comparative advantage in part of this market.

43In the US, not only do hardware manufacturers spin off software companies, but they also spin off large number of independent start-ups. Lotus Development Corporation, for example, has spun off over 30 independent software houses.
The IT industry in general, and software services in particular are fast changing, thus imposing substantial information and training requirements on all enterprises that produce or use IT products and services. A recent survey\(^4\) suggests a strong demand for information in many technological areas by the majority of small and medium hardware and software enterprises. These areas include: ISO-9000 and specific steps and processes to improve quality; use of Computer Aided Design (CAD) in the electronics and computer industry; maintenance of peripherals; advances in micro-processors and electronic storage devices; investment and sourcing strategies for adoption of selective automation; software and open systems for networking; information on various national network facilities available to users and their pros and cons; potential of multi-media and ways to integrate multi-media solutions into networks; software engineering and tools; software project management; logistics of off-site software development; and new trends such as client-server computing and object-oriented methodologies.

The information needs of small IT suppliers and users are substantial and are likely to continue to grow and change in line with the fast pace of technological change and the growing complexity of systems solutions. The current information infrastructure, including libraries and scientific and technical databases and extension services, is highly under-developed and unlikely to respond adequately to the technology-intensive nature and fast pace of the IT industry.

**Standards.** A key area in building technological competency is technical standards development and quality enhancement. Various programs to promote quality and standards development in the IT sector have been pursued, among others, by the Department of Electronics and the National Productivity Council (NPC). An arm of the NPC (set up under an Indo-German Technical Cooperation scheme) has recently launched a special service on applied software measurement and benchmarking to increase productivity and quality for software companies. Much more is needed to accelerate the process and meet the increasingly demanding international standards for software quality and reliability.

**Marketing.** Specialized marketing institutions and software publishers are missing from the Indian software scene. Recent efforts to arrange delegations and seminars abroad and in India--by the DOE, the Electronics and Computer Software Export Promotion Council (under the aegis of the Ministry of Commerce), and NASSCOM--have helped to raise awareness of India’s potential as a software exporter. But information on domestic and foreign markets remains scarce and could benefit from support institutions that would carry out regular and systematic market surveys, workshops, and promotion--and recruit foreign partners with strength in marketing.

**User associations.** The underdeveloped domestic market for IT is reinforced by the limited resources and institutions devoted to informing, educating, and supporting IT users on the benefit and pitfalls of adopting and managing this technology. A recent trend that needs

\(^4\) The survey has been conducted by Tata Consultancy Services in October 1993 under a World Bank-financed Electronics Industry Development Project.
to be strengthened is the emergence of user associations to articulate the interests of IT users, help diffuse IT in their sectors, and provide channels for information and experience sharing among users, and with IT suppliers. The Confederation of Indian Industries (CII) is one promising example, the Indian Institutes of Management another. The organization of IT users, in both the public and private sectors, is crucial to the effective use and diffusion of this emerging technology.

Finance. The software industry is characterized by small enterprises, fast growth (typically about 30 to 40 percent annual growth), intangible assets and products, technology and product obsolescence, skill intensity, and innovation and entrepreneurship. These characteristics mean substantial expansion risks, high ratios of working capital, high upfront development costs, short product life cycles, large marketing expenditures, substantial learning costs, and fast response times. All those factors make this industry special in terms of financial services requirements, even though aggregate capital requirements of the software industry are relatively small.

Problem is: Indian financial institutions, lacking knowledge of the industry and its markets, have no reliable guidelines to give them assistance or confidence in evaluating software financing. Lending is based mainly on traditional manufacturing, where the means of production and outputs are tangible and the markets and technologies less volatile. Although the DOE has made the services of a few officers with expertise in evaluating software schemes available to the financial institutions, their services have not been utilized so far. Commercial banks normally do not provide finance for software product development consultancy services or for marketing—and they typically require detailed (and time-consuming) documentation.

Venture capital is one important source of financing for high technology industries and particularly for the software industry. It should be recognized that the Indian venture capital industry has started only recently, and has done well so far, and the long term prospects of the IT industry benefiting from such financing institutions are reasonably good. At present, however, India has few venture capital institutions, such as the Technology Development and Information Company of India (TDICI) and Risk Capital and Technology Finance Corporation (RCTC). With few exceptions, venture capital financing has been inadequate, as measured by the share of funding used by Indian software firms. For example, in the USA, about 40 percent of venture capital has gone to the IT field, mainly software and related new services. In India, venture capital is estimated to have met only 1 percent of the capital requirements of local software firms. Moreover, the availability of venture capital to software venture seems to be at an all-time low in India in the last year or two. Hence, appropriate finance remains a critical and pressing issue at this stage of development for a dynamic and internationally competitive Indian software industry.

Two recent developments are also encouraging. One is the growing foreign investment in India’s software industry. Many successful Indian companies have been financed to some degree by an injection of external capital. The second is the recent spurt of software companies going for public issues.
Informatics Labor Force

Software sector employment has expanded rapidly in many countries, including India, often during sluggish employment growth in the rest of the economy. Employment in the software industry increased faster in India than in most other comparator countries (Table 8). As shown in the Table, India has approximately 71,000 software and services professionals.

The pool of scientists, engineers and related professionals in India is large, but only a relatively small number in that pool are trained for or employed in informatics. Despite being small, the IT industry in India is diversified and complex, as in other countries, and it has many associated industries and services. To discuss the demand for IT personnel, it helps to distinguish those who produce and deliver IT and those who use and apply IT. The literature on informatics usually narrows the focus to three categories: informatics specialists—people who have been trained in information science and technology, including such specialized users as librarians, communications specialists—people trained in the technical and business aspects of the various forms of communications (satellite, telecommunications, broadcasting), and software and computer specialists—people trained in computer hardware manufacturing and maintenance or in computer software design and maintenance. Here, we use these three categories (of those involved in the production of IT), despite the much larger (but difficult to measure) demand for skills to apply IT in all sectors of the economy.

Informatics specialists. The demand for people trained in informatics has not been systematically investigated in India—except that for librarians met largely by programs in library science, but with little emphasis on advanced techniques, such as mapping, optical storage (CD-ROM), and computerization. These programs do not produce information specialists who can deal with the broad issue of designing and managing large data bases or with expertise in information analysis, information resource management, and communication and dissemination techniques. There are no formal graduate or postgraduate programs in informatics, as there are in developed countries, but The Board of Governors of the Indian Institute of Technology (IIT) in Bombay recently decided to develop such a program. It will take several years, however, before the program is running, and even longer before it will turn out graduates. Moreover, a single program producing 30 specialists is too small for India.
Table 8: Comparison of Software Industry Employment

<table>
<thead>
<tr>
<th>Number of Software and Services Professionals</th>
<th>ISRAEL (K)</th>
<th>CAGR %</th>
<th>IRELAND (K)</th>
<th>CAGR %</th>
<th>SINGAPORE (K)</th>
<th>CAGR %</th>
<th>INDIA (K)</th>
<th>CAGR %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic market (packaged software and professional services)</td>
<td>9.7</td>
<td>10%</td>
<td>3.23</td>
<td>10%</td>
<td>5.3</td>
<td>8%</td>
<td>9.00</td>
<td>12%</td>
</tr>
<tr>
<td>Import</td>
<td>7.0</td>
<td>15%</td>
<td>6.00</td>
<td>20%</td>
<td>4.6</td>
<td>10%</td>
<td>56.00</td>
<td>15%</td>
</tr>
<tr>
<td>Export market (software and professional services)</td>
<td>2.3</td>
<td>12%</td>
<td>3.54</td>
<td>12%</td>
<td>2.1</td>
<td>15%</td>
<td>5.50</td>
<td>12%</td>
</tr>
<tr>
<td>Export market (support services)</td>
<td>0.3</td>
<td>15%</td>
<td>1.30</td>
<td>15%</td>
<td>1.2</td>
<td>12%</td>
<td>0.80</td>
<td>12%</td>
</tr>
<tr>
<td>Total</td>
<td>19.3</td>
<td>12%</td>
<td>14.07</td>
<td>15%</td>
<td>13.2</td>
<td>10%</td>
<td>71.30</td>
<td>14%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number of Software and Services Professionals</th>
<th>CHINA (PRC) (K)</th>
<th>CAGR %</th>
<th>PHILIPPINES (K)</th>
<th>CAGR %</th>
<th>MEXICO (K)</th>
<th>CAGR %</th>
<th>HUNGARY (K)</th>
<th>CAGR %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic market (packaged software and professional services)</td>
<td>22.0</td>
<td>20%</td>
<td>7.50</td>
<td>12%</td>
<td>9.7</td>
<td>15%</td>
<td>5.83</td>
<td>-1%</td>
</tr>
<tr>
<td>Import</td>
<td>42.4</td>
<td>35%</td>
<td>30.00</td>
<td>13%</td>
<td>37.0</td>
<td>12%</td>
<td>15.56</td>
<td>2%</td>
</tr>
<tr>
<td>Export market (software and professional services)</td>
<td>1.5</td>
<td>25%</td>
<td>1.50</td>
<td>18%</td>
<td>1.3</td>
<td>17%</td>
<td>1.42</td>
<td>0%</td>
</tr>
<tr>
<td>Export market (support services)</td>
<td>2.5</td>
<td>27%</td>
<td>4.00</td>
<td>15%</td>
<td>0.6</td>
<td>17%</td>
<td>0.03</td>
<td>1%</td>
</tr>
<tr>
<td>Total</td>
<td>68.6</td>
<td>30%</td>
<td>43.0</td>
<td>13%</td>
<td>48.6</td>
<td>13%</td>
<td>22.84</td>
<td>1%</td>
</tr>
</tbody>
</table>

CAGR = Cumulative average growth rate.  
K = 1000
**Communications specialists.** There is a well established demand in India for electrical and electronics engineering personnel -- employed by the Department of Telecommunications (DoT), NIC, Ernet, C-dot, and similar organizations. The demand for telecommunications specialists has been growing gradually in the last five years in parallel with the expansion of satellite, telephone, and radio and TV transmission and broadcasting capacity in the country. It is likely that the demand for telecommunications specialists is going to increase very rapidly in the next few years. The main reason is that the demand for telecommunication services by private sector firms is expanding, particularly for international communications services. The software industry, too, is seeking greater access to international communications in order to deal with their overseas clients and to gain access to the overseas market for software. Other businesses are also demanding more and better communication services and access to domestic and international information and value-added services. All this will increase the demand for communication specialists.

**Software and computer specialists.** The core of an informatics labor force is its software personnel. In India the demand for trained software personnel far outstrips the supply, and the shortage is a major constraint to the industry’s expansion. It places a heavy training burden on firms, results in high staff turnovers, and reduces the quality and competitiveness of the industry. Why the shortage? One reason is the substantial attrition of engineering school graduates, particularly from the IITs, and of experienced software professionals as a result of bodyshopping practices. Others include the scarcity of teachers and trainers, particularly in public education institutes, the irrelevance and poor quality of public and private (proprietary) training programs, and the high cost of in-house training.

**Narrowing the gaps.** Several manpower projections--made in the past few years by the Department of Electronics (DOE), Dataquest, and others--are unreliable because of the general lack of base line data and the uncertainties about the rate of expansion of different segments of the industry. There also are difficulties in differentiating between jobs in different segments of the industry--in computer hardware companies, in computer software companies, and in computer applications jobs in industry and services. In addition, there is even less information about the demand and supply for different categories of jobs: data entry, programming, system analysis, software engineering, and project management. But the main gaps appear to be in personnel for computer software and computer application firms (Annex 3). To reduce the imbalances, computer applications (user) firms will have to do much more in-house training if they want to continue, let alone accelerate, the automation of their operations. The output from the public sector institutes is growing very slowly, constrained by the lack of teachers and funds for operating and capital costs. But such institutes are the only ones that can award degrees. Given the preference for academic qualifications by firms and students alike, this will be a major constraint--unless the government allows qualified private and in-house training organizations to grant equivalent qualifications.

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45The Electronics Industry Development Project has a major manpower development component, which focuses on electronics engineering and related skills -- for computer hardware and industrial (control) electronics among others. This paper focuses on software manpower, not covered under that project.
The Government could help the universities establish programs in software engineering in collaboration with computer software firms, industry associations, and universities abroad. The government may also upgrade the Masters in Computer Applications (MCA) programs to make them more responsive to the industry, expand the use of contemporary computer systems, incorporate case studies into curriculum, and upgrade the curriculum of the Engineering and Computer Science programs of the universities. Some discussion is already going on about this possibility and initial contacts with universities in the US have been made.

The capacity of the private training organizations has been expanding rapidly over the last few years. These organizations now produce almost 85 percent of the programmers and 40 percent of the systems analysts. A high priority is to help (viable and promising) private training organizations improve the quality of their training and expand in areas where they have an advantage. And to stimulate in-house training, a system of incentives and a form of apprenticeship are needed. If firms take on apprentices and provide opportunities for them to learn with the help and guidance from an experienced supervisor, that could substantially increase the supply of trained persons for the software industry.

Quality and relevance of training. In the public sector, the quality and relevance of the training programs is very low. Only 275 industrial training institutes, polytechnics, colleges, and universities are qualified (and receive support) to conduct computer training programs. But most of even this small number face shortages of qualified teachers, adequate equipment, and software and books—and they have weak links with industry and users (despite a 50 percent increase in the number of MCA graduates in 1991, only 5 percent were hired by software exporters). Because of the irrelevance of the training, employers prefer to recruit from only a few of these institutes (one large software house considers undergraduate and graduate students from only 30 universities).

In the private sector, an estimated 1,000 proprietary organizations turn out about 80,000 trainees annually from courses ranging from two weeks to two years. Industry specialists estimate that 98 percent of the training organizations are below standard. Few of the graduates find employment, after paying fees ranging from RP 800 for two months to RP 8,000 for a one-year course. The Government is considering regulating the proprietary training organizations and setting quality standards, but nothing has been done up to now. Only about 10 to 14 of the larger organizations offer good-quality programs. Between them they train roughly 40,000 trainees a year, with about 30,000 in basic two year programs to qualify for entry positions as programmers. The proprietary organizations also conduct executive training programs for computer and management personnel—mostly for large companies.

The expansion of proprietary training organizations has been rapid and the large ones have been doubling their capacity and output the past few years. There are three issues concerning such training. First, the Government may want to consider allowing qualifying organizations to offer degree (or equivalent) training and qualifications. Secondly, to facilitate the expansion of private training (which is taking on an increasingly larger share of the training burden), the Government may extend concessionary financing for qualifying organizations.
Thirdly, it would be necessary to draft regulations that would curb the spread of fly-by-night computer training centers that are unable to provide training of an acceptable standard and/or force centers to improve the quality of training. Also, education and employment agencies and industry associations should be encouraged to inform trainees about the quality and reputation of private training centers.

The quality of in-house training is also generally inadequate--but it usually is highly specialized, focusing on skills relevant to the employer. In-house training should be promoted since it contributes to the productivity and competitiveness of the software industry. But, small and medium-size firms tend to do very little in-house training--for two reasons: the high cost of training, and the fear that employees will leave for more lucrative jobs once they have more job skills. To encourage in-house training, the government might consider extending incentives to computer and software firms to increase the skills of existing personnel and to take on apprentices.

The ongoing policy reforms, particularly those directed at the public sector and labor market, could have significant impact on releasing many IT specialists from their MIS organizations, and their re-deployment into private agencies and non-restricted environments with the requisite professional growth potential and challenges. However, positive measures and retraining incentives and programs may be required to accelerate the recycling of these under-utilized human resources.
V. STRATEGIC ELEMENTS AND OPTIONS

The information technology sector may be viewed as a source of productivity growth in all economic sectors—that is, as an important infrastructure—and as an industry in its own right. This study supports both views but emphasizes the first, since this is where most of the benefits are likely to come from for latecomer industrializing countries. Governments can play a catalytic role in developing this infrastructure and in piloting and demonstrating various services to utilize the new infrastructure and stimulate the effective use of these services in support of economy-wide competitiveness.

As an industry, information technology is perhaps the largest, fastest growing and the most profitable industry in the world today, and India already enjoys competitive advantage in the fastest growing segment of this industry, namely, software. However, if India is to remain competitive in the software industry and avoid falling behind other countries that have targeted informatics as a strategic sector, it will need to devise specific programs, policies, and institutions to accumulate skills and build markets faster than the competition. This will require a strong, coherent, and well-designed strategy, with mutually reinforcing and concentrated efforts by government agencies and private firms. Fortunately, India can draw on the accumulated lessons of experience of OECD countries and the newly industrializing economies (NIEs) in promoting this sector.

Country Experiences in Informatics Development and Diffusion

Substantial experience is accumulating in OECD countries, and the NIEs, concerning successful policies and programs to develop and diffuse information technology. In all these countries, the Government is active in promoting the development and diffusion of informatics, and their policies and programs span many IT areas (see Figure 5). Some of these policies and interventions have been more effective than others, for example, the use of subsidized private consultancy services rather than government extension services to diffuse promising information technology applications among small and medium enterprises. Other policies proved counter-productive, for example, the focus on local hardware production and the targeting of national champions to the neglect of domestic use and diffusion, and the development of software services. Recently, there has been a shift in emphasis toward diffusion and toward the development of software capabilities. (A detailed description of IT diffusion measures common in OECD is in Annex 5).

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44 This section draws on the substantial work done by the OECD Industry Committee, OECD Development Center, OECD/ICCF, and SPRU of Sussex University, among others.

47 Kenneth Arrow (1962) captured the traditional arguments for government intervention in research: indivisibility, inappropriability and uncertainty. With respect to information technology diffusion, at least two reasons must be added: capability failures (shortfalls in technical skills to adopt, organizational inadequacies, infrastructural rigidities, poor understanding) and information failures (inadequate availability of information on new technology, asymmetries, and biased information from suppliers). These failures are particularly common among small and medium-size enterprises.
<table>
<thead>
<tr>
<th>DEMAND SIDE</th>
<th>ENVIRONMENT/INFRASTRUCTURE</th>
<th>SUPPLY SIDE</th>
</tr>
</thead>
<tbody>
<tr>
<td>(IT users)</td>
<td>(bridging demand &amp; supply)</td>
<td>(IT suppliers)</td>
</tr>
<tr>
<td>Information dissemination</td>
<td>Strategy formulation and coordination</td>
<td>Research</td>
</tr>
<tr>
<td>- awareness activities, national seminars, visits</td>
<td>- coupling supply and demand initiatives, organizations, policies</td>
<td>- R &amp; D programs and consortia</td>
</tr>
<tr>
<td>- market research &amp; development</td>
<td>- strengthening coordination, monitoring</td>
<td>- R &amp; D loans</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- R &amp; D tax incentives</td>
</tr>
<tr>
<td>Demonstration projects</td>
<td>Information Communication Infrastructure</td>
<td>Research Institutions</td>
</tr>
<tr>
<td>- process application support</td>
<td>- private participation in value-added services</td>
<td>- strengthening &amp; restructuring</td>
</tr>
<tr>
<td>- product development support</td>
<td>- competition</td>
<td></td>
</tr>
<tr>
<td>- public administration modernization</td>
<td>- investment in telecommunications and data communication infrastructures</td>
<td></td>
</tr>
<tr>
<td>Adoption incentives</td>
<td>Standardization</td>
<td>Export promotion programs</td>
</tr>
<tr>
<td>- consultancy assistance</td>
<td>- to strengthen supply &amp; to facilitate adoption</td>
<td>- Foreign recruitment &amp; strategic alliances</td>
</tr>
<tr>
<td>- tax incentives</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technological capability development</td>
<td>Legal framework</td>
<td>Industrial policy/strategy</td>
</tr>
<tr>
<td>- adoption skills development</td>
<td>- software protection</td>
<td>- access to foreign technology</td>
</tr>
<tr>
<td>- decentralized application centers</td>
<td>- access to public information</td>
<td>- assistance to small enterprises</td>
</tr>
<tr>
<td>- extension schemes, consultancy development</td>
<td></td>
<td>- special finance to software firms</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- subsidy to national champions</td>
</tr>
<tr>
<td>Procurement</td>
<td>Education</td>
<td>Software quality &amp; productivity</td>
</tr>
<tr>
<td>- public procurement policies</td>
<td>- electronics &amp; software engineering</td>
<td>- enhancement programs</td>
</tr>
<tr>
<td></td>
<td>- managers &amp; professionals</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- computer literacy</td>
<td>- specialized services &amp; common facilities</td>
</tr>
<tr>
<td>IT users/consultancy associations</td>
<td>Competition and trade policies</td>
<td>IT industry &amp; trade associations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- strengthen, use, link</td>
</tr>
<tr>
<td>- strengthen &amp; use professional associations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- clearinghouses, info. networks</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figure 6: Singapore's Information Technology Strategy

IT National Plan

National Computer Board
- Collaboration among Public & Private

IT Culture
- Assist user associations
- Exhibitions and awards

Recruiting multinational IT companies
- Foreign Software Development Centers

Software Industry Development
- R&D incentives
- Soft loans
- Foreign market development
- Software industry partnership
- Shared facilities/demo centers

IT Education and Literacy
- Universities
- IT user training
- Accreditation schemes
- Computer literacy in schools

Industrial Policy

IT Policies
- IPR
- Standards
- Government procurement

IT Extension to SMEs
- Low cost training
- Subsidized consultancy
- Standardized software for industries
- Low-cost loans

IT Innovation Centers
- Resource centers for user
- Prototype development

Government Computerization
- Civil service computerization
- Common databases
- Port computerization

Networked Users (EDI)
- Trade, medical, education & law net

Modernization of Telecom
Essential for all countries, technology development and diffusion are complementary, though the balance between them will vary. Diffusion activities allow existing and new technologies to be exploited, while research and technology development are essential to provide high level technical personnel and to access new technical advances. For developing countries, however, the balance should be even more in favor of technology diffusion. (See Annex 6 for details).

Consider Singapore: It formulated a national IT strategy with a primary emphasis on IT diffusion. The strategy is the product of intensive and continuous collaboration between Government agencies and the private sector; strategy development is led by the National Computer Board. The main elements of Singapore’s strategy are: informatics policy and institutional development, informatics manpower and computer literacy, telecommunications and specialized networks, demonstration projects in the public and private sectors, support infrastructure for the software industry, and IT diffusion programs for small and medium enterprises (Figure 6).

As dominant users of information technology, governments in OECD countries and the NIEs have played a key role in creating data communication infrastructures (such as INTERNET in the USA and TradeNet in Singapore), setting standards for hardware and software, promoting competition, and separating hardware from software services (and thus creating an independent software industry). Governments thus influenced the overall development of the IT industry. They have also invested heavily in the computerization of key public and social services, tax and customs administration, public financial management, public infrastructures, and public information services. More recently, public sector agencies are learning to use information technology to promote decentralization, coordination and accountability. During this process, many mistakes were made and lessons learned.

The main lessons in applying information technology in public administration and infrastructure are:

- Public agencies should rely as much as possible on contracting out systems development and computer support services to the private sector, in view of the fast pace of change in IT and the limitations on the civil service to develop and maintain a large and responsive in-house information systems organization;

- The public sector must strike the right balance in decentralizing the planning and management of its information systems. The center should provide strategic directions, key standards, policy frameworks, and perhaps a catalytic role through demonstration projects and the introduction of best practices in public agencies. However, excessive centralization would deprive public agencies of the necessary flexibility to exploit technological advances and to orient IT investment to their priorities and business needs;
The lack of any central oversight and a critical mass of in-house expertise in the public sector often hinder the sharing of information, common applications, bulk procurement, and lessons of experience, and the development of information standards and protocols and common information infrastructures.

A central capability in the public sector should provide: (a) policy guidelines for IT procurement; (b) training and occupational streams for informatics professionals; (c) technical assistance in information requirements analysis and systems planning, (d) standards for information and communications; and (e) a critical mass of expertise for planning and contracting out the development of strategic systems and applications, such as public databases and networks.

Organizational and human factors are even more critical to computerization in the public agencies, and particularly to the realization of strategic and transformation benefits. In industrial countries, as public agencies have learned to use IT to improve productivity, they have proceeded to learn to use IT to enhance services, responsiveness, and accountability. Best practices are emerging to address these factors, including ways to involve top management in leading the process and to analyze the information needs of various stakeholders and clients of public institutions.

While IT application and learning mainly occur at the institutional (and enterprise) level, there is a strong case to be made for developing national policies, programs and infrastructures that would set broad priorities, target strategic applications and demonstration projects, invest in common databases and data networks, and share information and experience among government agencies. The experience of Singapore with its civil service computerization program, among others, suggest the extremely high payoffs from a coherent strategy and prioritized program for public sector computerization. The Bank’s experience in IT lending also suggests that a public sector-wide view of computerization needs would be likely to identify those key information infrastructure bottlenecks and broad areas of applications with the highest possible impact on a country’s development strategy.

For emerging lessons from the Bank's own lending to information technology applications for public agencies in developing countries, see Nagy Hanna and Sandy Boyson, "Information Technology in World Bank Lending", World Bank Discussion Paper, 1993.
The rationale for a government role in technology development and diffusion in industry (and the private sector, in general) has been extensively discussed in the economic literature, and more recently in several Operations Evaluation Department reports. Briefly put, the process of moving up the technological ladder and mastering new technologies requires conscious and sustained effort. The determinants of this process include incentives, capabilities and institutions. Competition, both domestic and foreign, is a powerful incentive to technological development and diffusion. The regime for intellectual property rights is also critical for local firms to create new technologies, and to have access to foreign technologies, and this is an important issue for the software industry. But incentives alone are not sufficient to ensure supply response and effective technology adoption. This may be particularly the case for fast changing technologies, or when fundamental technological change occurs, as early adopters then face major uncertainties, information failures, and substantial learning costs and externalities.

In strengthening supply response and accelerating the effective diffusion of information technology, all developed countries and a growing number of NIEs have invested in setting up specific programs and institutions to augment the functioning of skill, capital and information markets that are relevant to IT capability development and diffusion. Information technology in particular calls for new and specific skills and for close interaction between educational institutions and the users of the specialized technical manpower, such as software engineers. The training provided by the suppliers and users of IT is even more critical to successful diffusion and such training suffers from several market failures. Since IT is a relatively new and fast changing technology, and since software engineers are in short supply globally, firms in India and other countries are relatively unaware of the benefits to be derived from investments in such training, and face a significant risk that trained manpower will leave the firm, and thus underinvest in capability development. Substantial externalities also exist in learning to manage the new technology.

Other areas for government role concern capital market and information failures. Intangible investments in information systems and services and the introduction of micro-electronics into products and processes face uncertainties and risks similar to those associated with research and development. The financial system is often not ready to respond to such investment requirements, and this is the case even among developed economies.

Institution-level efforts to invest in and manage information technology have to draw heavily on information from external sources, including suppliers and consultants, and

inputs from technology institutions, and from overseas. Even large firms find it too costly to collect information on alternative information technologies, sources and prices. This is particularly the case for imported and fast changing technologies. The most successful countries like Korea and Japan, have helped importers and adopters of IT by developing specialized agencies or programs for information acquisition and dissemination. The problems of inadequate availability of reliable information on technology choices, of biased information from suppliers, and of information asymmetries between multinational suppliers and local users are pervasive in information technology and most acute among small and medium-size enterprises.

The main lessons about policies and programs for IT diffusion in industry and services are as follows:

- The policy context is crucial. It includes trade, industrial, technology and competition policies—as well as IT-specific policies to improve access to, and to create markets for information technology products and services (as through public procurement).

- Governments can lead or play a catalytic role in developing IT manpower, computerizing public administration and financial services, diffusing IT application among small and medium-size enterprises, promoting software and computer services, mobilizing local and global information resources, and inducing collaboration among public, private, academic, and foreign agencies.

- Technology parks and incubator facilities that provide shared infrastructure and support services are important for clustering and networking, and for providing key services for small and medium software and information services firms.

- Demonstration projects can be extremely persuasive in addressing the entrepreneur's and technologist's skepticism. These projects should involve real users in real work settings, not showpieces in research institutes.

- Collaboration among suppliers and users is often necessary to match supply with demand—and networks, clearing houses, intermediaries, private associations, and other channels are vital to effective adoption and diffusion of new information technologies.

- Consulting and extension services, often subsidized for early adopters of IT, are especially important for small and medium-size enterprises. IT adoption often requires changes in core business processes, so the risks go beyond the investment costs for IT. For small and medium-size enterprises, diffusion programs typically use cost-sharing to reduce risk and induce users to take manageable risks.

- The business problems and technological capabilities of users should be well
understood to design diffusion programs. Potential users need to see the business rationale for adopting information technology and the ways it can improve their competitiveness.

- Firms need complementary human resource development programs for adopting and managing information technology.

Towards a Strategy

An IT strategy for India would view information technology as an enabling infrastructure that can facilitate the implementation of India's new development strategy and prepare the country for competing in the 1990s and beyond. Recent industrial, trade and financial policy changes have liberalized what was one of the most closed and regulated economies in the world. To deepen the reform--and perhaps more important, to strengthen the supply response (and export performance) and build the base for long-term competitive advantage--India needs to address some of India's key infrastructure and capability constraints. Informatics is one such constraint. Not an end in itself, IT presents a unique opportunity and substantial promise to address India's key development priorities. A national information infrastructure also builds the base for an economy that would be able to compete in an increasingly information-intensive global economy.

Basic Objectives

Informatics development could play four major roles in support of India's development strategy. It could:

- Enhance exports, particularly software exports--by facilitating logistics, increasing the productivity, quality, and flexibility of manufacturing, modernizing the transport and telecommunications infrastructure, and attracting foreign investment. India's new policies for trade and industry make information and communication services a key need for both businesses and Government.

- Promote private sector development -- by modernizing financial services, mobilizing and disseminating public information, reducing information failures and transaction costs, improving access to legal and regulatory information and to industrial standards information, creating a dynamic IT industry, and modernizing services and management systems.

- Improve public sector management -- by facilitating coordination and

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Figure 7. Possible Elements and Programs

Strategy Elements

Policy, Capability & Infrastructure Development

Information Use & Diffusion (Demand)

Software Industry Development (Supply)

Programs

1. Informatics Policies & Institutional Development
2. Informatics Manpower Development
3. Data Communications Development

4. Financial Sector Modernization
5. Public Sector Modernization
6. IT Diffusion to SMEs

7. Finance for Small Software Enterprises
8. Software Quality Improvement
9. Software Marketing & Export Promotion
10. Technology Parks & Shared Facilities
decentralization, modernizing information and communication systems, improving databases for policy analysis and monitoring systems, improving the planning and monitoring of public expenditure, introducing managerial innovations and decision support systems, and modernizing large transactions systems, such as tax administration, land records, and the treasury.

- Alleviate poverty and accelerating learning and human resources development—perhaps by reducing the pervasive forms of information poverty,\(^{31}\) improving the management and monitoring of poverty alleviation programs, improving agricultural extension, improving learning in and out of schools, and extending health and educational services to remote and under-serviced areas.

Main Elements and Options

For information technology to play such roles will take major changes in India’s IT policies and practices—in support of its new economic development strategy. Reentering the fast-changing global market implies major transformations for the national information and communication systems, for the institutions and policies that generate and diffuse technological change, and for human resource development programs.

The following are some possible options. Some aim at mobilizing demand and facilitating the diffusion of informatics and the adoption of best practices in key economic sectors. Some address key supply constraints to the development of the software industry and some aim to foster the necessary capabilities, institutions, policies, and other aspects of the information technology infrastructure. See Figure 7, which links the possible elements of a national IT strategy.

(a) Mobilizing Demand

India’s IT strategy may view informatics as a source of modernization—and of enhancing competitiveness. Criteria for selection of IT application areas would be those which would directly support India’s development strategy, have the highest payoff from using information technology, and generate learning opportunities for the local software industry and externalities and demonstration effects for users. These criteria suggest five broad areas spanning the public and private sectors:

1. logistics, particularly ports, customs, rail transport, and trade information;
2. core public transaction systems, such as tax administration, land records management, and treasury management;
3. planning, monitoring, and management systems of major national programs for human resources development and poverty alleviation;

\(^{31}\)The poor suffer from limited access to information, as producers, consumers and learners. See, for example, Communication, Participation and Democracy, Society for International Development, 1990:2, and The Information Technology Revolution and Economic Development, World Bank, 1991.
financial institutions, particularly the commercial banks; and

small and medium enterprises, in sectors where IT would have major role, such as in engineering, garments, and export-oriented industries.

Among these areas, priority needs to be given to modernizing key infrastructures and services, and to developing selected elements of a national "info-structure", whose nature is one of creating and delivering public goods.

National programs to mobilize demand for IT and speed its diffusion would be needed: to

- compensate for weak links between suppliers and users and for the predominance of small software firms (with their limited scale for R&D, training, marketing, and information searches).
- compensate for failures in the information market (information or knowledge, is a highly imperfect commodity).
- aid small and medium enterprises to overcome information asymmetries, acquire the knowledge needed for adopting IT, and manage the risks associated with IT-based process and product innovations.
- create advanced local users who would push suppliers to adapt products to local needs and would promote diffusion through their own innovations to adapt technology.
- create a critical mass of users which is essential to widening the pool of skilled manpower, enhancing local consultancy and support services, sharing of best practices, and greater understanding of IT costs and potential.
- capture the "dynamic externalities" of IT arising from market complementarities; from spill-overs to downstream industries; from cumulative (and collective) learning by doing, using, and sharing; and from interactions among various information technologies.
- strengthen the technological infrastructure that facilitates the transfer of technology from developers and suppliers to users.
- tackle specific obstacles to the diffusion of technology, such as low awareness and the lack of skills.

As the largest user of IT, the government also plays a direct role in creating demand for IT products and services. Many countries have used computerization programs in public administration to realize direct benefits from specific applications—and to generate

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*See Annexes 5 and 6 for OECD and NIEs experiences with IT diffusion programs and the role of government.*
demonstration effects, learning opportunities, and competitive markets for local suppliers—particularly important for the software industry. Government policies and practices to improve access to public information resources by the information services industry also create competitive local markets for information products and services and, in turn, help improve country-wide competitiveness and the functioning of all factor and product markets.

5.1 The National Informatics Center (NIC) can play a crucial role in promoting best practices and diffusing IT in public agencies. It could help agencies in acquiring the most appropriate IT services from the private sector. It could provide technical advice, standards setting, and oversight functions on behalf of the Ministry of Finance and the Planning Commission on government-wide computerization programs. But NIC should not be given monopoly power as an information system developer for government. Rather, the NIC should be restructured to strengthen this promotional and standard-setting roles. NIC could also play a catalytic link between the public and private sectors in establishing India’s information infrastructure.

(b) Strengthening Supply Capabilities

The strategic thrust in computer hardware and industrial electronics should be to ensure competitive supply and specialization. The national policy should be such that it would nurture only the most promising segments, access international technological knowhow through joint ventures, and progressively reduce the high tariffs and restrictions on computers and electronics components, and thus make the technology available to domestic users as quickly and cheaply as possible. Only in a large and competitive domestic market could this industry support the overall national development strategy. It is critical that industrial and trade policies make available the latest hardware platforms and software development tools at internationally competitive costs to allow software developers to compete internationally—and to promote diffusion.

India’s aspirations to develop the software industry as a major export and foreign exchange earner are well known. But unlike other successful countries in this area, India has neglected its vast domestic needs for information systems and services. The "body-shopping" syndrome of Indian software exports sends the best talent to work for foreign clients, often for low value-added services. For a fast-changing, technology-intensive sector such as informatics, it has also created an enclave, with weak links between local software firms and the domestic industry—this, in an industry where interactions between suppliers and users are essential. A broad-based software industry is essential for sustained and competitive export.

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5 A major benefit of having an electronics industry, especially industrial electronics and computers, is the impact on subsequent users. In some product groups or technologies, there are strong interdependencies between manufacturer and customer in product development and support. These technologies tend to be also skill-intensive. India’s potential competitiveness in computers and industrial electronics is based on skilled manpower in design (India’s strength) and downstream services in sales, maintenance, and systems development and integration. See O. Gowen and D. Heffler, "The Electronics Industry in India: Past Problems, Recent Progress, Future Outlook," mimeo, 1989.
Exploiting opportunities abroad also requires sophisticated marketing, which few Indian software companies can do today. Marketing programs to build strategic alliances with foreign partners would be a key element of developing the software industry.

Proposals to strengthen supply capabilities may cover the following six areas. The first is building skills and developing appropriate policies and programs within selected financial institutions to meet the special financing needs of small and medium-size software enterprises. The second is providing incentives and extension services through appropriate intermediaries to upgrade the productivity and quality of software development processes of local software firms to meet increasingly demanding international standards. The third is establishing software parks with the communication infrastructure and common services to serve export-oriented software firms. The fourth is developing programs to strengthen the marketing capabilities of software firms and to recruit foreign partners and develop marketing channels for export. The fifth is restructuring the promotional and standard-setting role of the National Information Center (NIC) to help public agencies in their modernization programs. Finally, the Government may consider privatizing the Computer Maintenance Corporation (CMC), to ensure that the substantial technical capabilities of this enterprise become market-driven and to enable the enterprise to mobilize private resources in support of its export drive and globalization strategy.

(c) Formulating Policy and Developing Infrastructure

Informatics development and diffusion depend heavily on infrastructure and policy. India may therefore consider:

1. Developing an IT workforce for software exports and for the effective use of the technology in key sectors.

2. Modernizing the data communications infrastructure and developing a competitive market for data communications and value added services.

3. Developing national informatics policies--and capabilities for policy development and coordination.

Developing an IT workforce. Perhaps the most important, the manpower development component of a national IT strategy would have two aspects. One would be to develop the technical skills needed by the local suppliers of IT, both for export and for the domestic market. The other would be to develop the broad skills needed by potential IT users and managers, in both the public and private sectors. Unless the pool of informatics manpower (particularly of software engineers) is expanded substantially, India's basic strengths--the low wages for high-quality systems engineers and programmers and the large pool of trainable manpower--will wither. And unless investments are made to educate potential end-users and to retool the labor force, it is unlikely that India will take advantage of IT applications in its own industries and services--or have the flexible workforce and institutions needed for a growing information-intensive economy.
Human capital formation will take special efforts by private training institutions, large software and computer hardware firms, foreign multinationals, and public education institutions. Key measures for the Government and private sector to consider would include:

(a) incentives to small software houses to invest in training;

(b) incentives to large software houses and multinationals to establish advanced training centers or provide educational programs beyond those required for their own staff;

(c) incentives to local hardware producers and suppliers to expand their customer training programs;

(d) certification of private training institutes, assistance in improving their quality, and elimination of unproductive regulations that govern their activities; and

(e) research and surveys on the informatics labor market and dissemination of results.

The public sector remains the main force in building an informatics workforce. Detailed information on quantitative and qualitative IT manpower requirements is lacking in India; they are typically difficult to measure or project into the future for such a fast changing field. However, key elements of a strategy for the Government to consider to improve and accelerate the development of an informatics workforce would include:

(a) establishing centers of excellence in informatics and software engineering in selected universities;

(b) strengthening links between universities and IT businesses;

(c) improving curricula and access to advanced computer facilities;

(d) introducing software engineering tools in computer science programs;

(e) introducing university courses in information science and IT management for non-IT professionals (engineers, managers); and

(f) promoting computer literacy through schools and the mass media.

Modernizing Data Communications. India has an opportunity to catch up and leapfrog in the adoption of modern telecommunications technologies. With obsolete or inefficient telecom infrastructure and limited installed base, India can take advantage of the technological discontinuities between electromechanical and electronic switching and the cut-
throat competition among global suppliers. The convergence of telecom, computing, software and microelectronics into a powerful technological system has substantially widened the scope of telecommunication networks and their possible applications. It has also created new technical requirements for reliability, capacity, speed, and compatibility that are difficult to add piecemeal to old networks. An aggressive modernization program—combined with selective procurement strategies and greater private involvement in telecom services—could help diffuse information and communication technologies. Meantime, interim measures to address current bottlenecks in data communication needs for software export are urgently needed.

Given the magnitude of the problem and the size of the country, there is a need to move in parallel and selectively invest in data communication networks for key national priorities and locations. At present, there is no forum or mechanism to identify these priorities. Investment in a high quality government-wide data network may spearhead the process. Coordination between various agencies and standardization are key to mobilizing investment in such priority networks.

Over the last few years, there has been a few regional efforts to develop high quality data network. One important effort supported by the State of Maharashtra is to establish a business network linking major industrial parks, universities and urban centers within the state. The proposed network is to be undertaken through a joint venture with multinational and local investors. At present, such local and private sector efforts are often hindered by the regulatory framework for telecommunications. A key element of the national IT strategy would be to encourage these regional efforts.

Developing policies. Informatics policy should aim at creating competitive markets for IT products and services: for computers, software, telecom services, value-added services, and information services. Public procurement policies and practices can help establish these markets and promote best practices. As a user and provider of information, the public sector may develop information policies to cover information standards, interagency data sharing and dissemination, coordinated investment in public sector databases, and the pricing of information services of public agencies. As a regulator, the government should further develop the legal framework for informatics—to cover the protection of intellectual property, the confidentiality of data, the value-added services of the private sector, the information standards for the financial markets, and the legal basis for electronic transactions. Detailed policy studies are needed for the government to effectively address this growing policy agenda.

Areas for Action Plan

For India, there are various options under six broad policy and program areas that would translate the above strategic elements into actions (Figure 7):

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34See, for example, C. Antonelli, The Diffusion of Advanced Telecommunications in Developing Countries, OECD, 1991.
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- Informatics policy and institutional development.
- Informatics manpower development
- Data communications development
- Public sector modernization
- Financial sector modernization
- Software industry development, and IT use by small and medium enterprises.

For an emerging sector with severe data limitations and embryonic policies and institutions, many of the proposed actions require further detailed design, feasibility assessment, pilot testing and continued adaptation. These limitations should not deter policy makers from timely action in a fast moving and strategic sector where other competing countries are also acting with speed, flexibility and determination.

Informatics Policy and Institutional Development

For IT-specific policy, government may develop the necessary public policies in four main areas: (1) public procurement to promote standardization, competitive markets, and best practices in information systems development; (2) intellectual property protection, to encourage domestic and foreign investment in software development; (3) access to public information and databases, to promote the development of private information services and exploit more fully the substantial but captive public information resources; and (4) elimination of import restrictions and reduction of tariffs on hardware and software, to promote competitive markets in IT products, and further develop the software industry. Progress in these areas—a minimum set of policies—would allow the government to develop a second generation of policies for information regulation, confidentiality, privacy, liability, computer crime, and the legal basis for electronic transactions. This second set would aim to build the legal infrastructure for an information-based economy.

An effective national locus for informatics policymaking in India is needed. A national capacity for policy analysis, strategy formulation, and promotion and monitoring should therefore be developed and strengthened. One option is to create a Software or Information Technology Development Board to provide the basis for an inter-ministerial mechanism to formulate informatics policies, and facilitate coordination, promotion, and dialogue among public agencies and private sector associations (IT suppliers and users). Coordination is particularly needed on public procurement policy, public information policy, public sector computerization, interagency communications, and export marketing. Lessons could perhaps be drawn from other countries’ experience in this area, including the highly effective Singapore National Computer Board (Annex VI). In the Indian context, the Board should be financed in part by the IT industry
Figure 8. DOE scheme to promote CAREER OPPORTUNITIES IN THE COMPUTER FIELD

1. PPDCA: Post Polytechnic Diploma in Computer Applications
2. PGDCA: Post Graduate Diploma in Computer Applications
3. ALCCS run by IETE is equivalent to M.Tech in Computer Science
4. MCA: Masters in Computer Applications

Source: DOE
Box 3: Options in Developing an IT Workforce

Human capital formation will take special efforts by private training institutions, large software and computer hardware firms, foreign multinationals, and public education institutions. Key measures for the private sector include:

(i) incentive to small software houses to invest in training.
(ii) incentive to large software houses and multinationals to establish advanced training centers or provide training programs beyond those required for their own staff.
(iii) incentives to local hardware producers and suppliers to expand their training programs.
(iv) certification of private training institutes, assistance in improving their quality, and elimination of unproductive regulations that govern their activities, and
(v) research and surveys on the informatics labor market and dissemination of results.

The public sector remains the main source in building an informatics workforce. Key measures to improve and accelerate this process include:

(i) establishing centers of excellence in informatics and software engineering in selected universities.
(ii) strengthening links between universities and IT businesses.
(iii) improving curricula and access to advanced computer facilities.
(iv) introducing software engineering tools for computer science programs.
(v) introducing university courses in information and IT use and management for non-IT professionals (engineers, managers) and
(vi) promoting computer literacy through schools and mass media.

or some endowment, should have strong private sector voice, and be led by public-spirited persons.

Promoting coordination within government and building bridges among public and private agencies and users and suppliers, are likely to require building on the essentially decentralized institutional framework for national IT policy and program management of India. The management of each national agency should lead the process of identifying the implications of IT for its own agency and develop a corresponding set of initiatives. The national IT strategy would support these initiatives and strengthen the capability of each major agency to become an effective manager of its information resources and an effective adopter of information technology. This may be provided through a common support infrastructure, such as the NIC,
combined with a growing and specialized consulting industry and a competitive domestic market for software services.

A national IT strategy may also consider strengthening other key IT institutions in the public and private sectors, and promoting collaboration among them on a variety of national and pilot programs. Assistance could take various forms, including the use of private associations to develop market studies and technology surveys and to deliver important training and support services, perhaps on a cost-sharing basis with the government and the beneficiaries. Candidates for institutional strengthening through targeted programs are NIC, NASSCOM, MAIT, NCST and CII.

Informatics Manpower Development

Various options and channels are available to the government and private sector to accelerate the development of informatics manpower (Box 3). In the public sector, there is a need to: upgrade teachers; attract more teachers by improving working conditions; upgrade equipment, software and the maintenance and repair services; and strengthen the link between training and employment through industrial attachment (students and faculty to work in industry on projects for specified period) and a system of seconding teachers from industry (experienced professionals to work as visiting faculty). The Department of Electronics (DOE) is already involved in developing curricula, setting standards, and financing computer training programs in education institutes. This effort should be supplemented with targeted activities for improving computer science and software engineering education. Universities would also benefit from joint ventures on training with universities abroad.

In the private sector, measures may be considered for upgrading the level of programs offered by large, well-established proprietary training organizations, and improving the quality of training at viable smaller organizations. One approach is the recently-developed scheme of the DOE, called the DOE Accreditation of Computer Courses (DOEACC), which attempts to impose some discipline and standards on various levels of private training institutions, and at the same time, provide alternative channels for consumers (trainees) to advance their careers and achieve market-recognized levels of proficiency (Figure 8). The scheme consists of two parts namely, accreditation and examination. Accreditation of training institutions is the joint responsibility of the DOE and two professional bodies: Institute of Electronics and Telecommunications Engineers (IETE) and the Computer Society of India (CSI). Private sector institutes meeting well-defined quality and service standards are given provisional accreditation for conducting certain standard courses. These courses range from basic programming (O level) to masters-level in computer science (C level). The examinations are conducted by CSI and IETE. This scheme provides flexibility for recycling graduates from various fields into information technology, and for meeting the different levels of skill needs in software development and programming. The scheme should be further assessed to assure adaptation in view of experience. It may be complemented by schemes to assist private training institutions to upgrade their services and meet accreditation requirements.
Box 4: A Case Study of In-house Training

Tata Consultancy Services (TCS) has just completed 25 years in software and management consultancy. One of the main reasons for the sustained growth of the company, both in the local market as well as abroad is the emphasis and priority that TCS gives to internal training. A rigorous and well-designed Initial Training Program enables TCS to convert raw talent of a very high calibre drawn from leading educational institutions, into productive and intelligent systems professionals who are equipped to face the dynamic and everchanging IT environment.

TCS has a Corporate Training Center at Bombay, and last year, this Center coordinated 6,000 program days or an average of 120,000 mandays of training. Elaborate training is given to new entrants, while there are Continuing Education Programs designed to acquaint senior professionals with new platforms, technologies and methodologies. TCS also conducts training programs in foreign languages like German, French and Japanese.

Every year, TCS spends 7 to 8 percent of its revenue on Training. Moreover, it invests considerable effort in developing and updating its various courses. Over 80% of the courses are developed by TCS technical staff, supplemented by academicians or experts from the industry from India and abroad both for designing the courses as well as cofaculty. Course development has a cycle by itself and is based on resource persons developing the material, various reviews by teams, dry runs, usage of aids and supplemented by case studies, quizzes, and hands-on exercises.

The training programs have enabled TCS to put its processes and methodologies in place before embarking on any project. The company firmly believes that unless it has an excellent local base, exports will be difficult or, at best, the company will be entrusted with only low level coding activity instead of turnkey project assignments.

Source: NASSCOM’s background paper for national workshop on IT diffusion, 1993.

Support for quality improvement could be private-sector led, and may be provided to private employer and professional associations to establish quality standards and draft regulations and disseminate comparative information to protect trainees, and respond more effectively to the skill needs in the country. To improve smaller viable organizations would require a system in which the industry, through its associations, would exercise quality control and perhaps provide incentives or approve financial support for trainees who enroll in bonafide training centers.

To improve in-house training by small and medium-size firms (large firms do a satisfactory job, see Box 4), a training fund may be established to provide incentives for firms to cover part of the cost of training, to be worked out by industry associations and the Government. This fund would have to be simple and transparent to avoid misuse; a training contract scheme—where a committee would review training contract proposals by firms and decide if the proposals would justify financial support from the training fund—would meet that criteria. This demand-driven approach is likely to be more effective than direct subsidies to training institutes. Another option, is to recognize the imperatives and risks involved in
continuous training in the dynamic world of software engineering, and provide tax incentives on
the same line as R&D.

Other options may be explored to address the managerial requirements of IT
suppliers and users. Special targeted training programs may address the common weaknesses
of small and medium software firms. These firms are typically managed by professionals with
technical background. But they often lack managerial and marketing skills. Similarly, the
software industry lacks project management skills and experience. Standardized courses may
be developed to improve skills in overseas marketing, business analysis, project management,
and quality management. Some government support towards sharing costs of the course material
and the training of trainers in these areas will have high economic pay offs in the form of
accelerating and leveraging human capital for a promising export industry. Government-industry
sponsored courses at the Indian Institutes of Management (IIM’s) would address the management
and marketing issues of the IT industry as well as the IT management issues in the user
industries.

A more substantial training and educational effort is required to address the needs
of IT users and the adjustments in the labor force that may accompany the broad diffusion of
IT. Three target groups are important: current business managers and public administrators,
professionals in various technical fields, and information scientists. The reasons: Managers and
policymakers are expected to formulate policies and strategies for the use of information and
communication systems for their institutions and businesses. Promoting computer literacy and
information management among educators, engineers and scientists would provide a broad basis
for the application of IT in all sectors. Programs for information scientists and other
information intermediaries would create a cadre of professionals to develop industrial and trade
databases, science and technology databases, legal and regulatory databases, bibliographic and
modern library services, and a variety of other information services. India may draw on the
experience of other advanced countries, particularly the NIEs in building an informatics
workforce, computer literacy, and IT awareness.

The design and implementation of a national program for informatics labor force
development is a complex and continuous process. The Government may therefore consider the
formation of an apex body involving Government, industry and academic institutions to design
and implement measures to strengthen the manpower development process. This body may also
develop accreditation schemes and standards, and review them on a regular basis to suit the
changing needs. This body may consider some bold and specific measures to augment current
supply, for example, by recycling graduates in other disciplines into software engineering,
inducing multinationals and NRI groups to participate in IT education, and establishing centers
of excellence in IT education on the lines of IITs.
One pressing issue that demands serious attention is the continuing, and perhaps increasing, brain drain. India continues to lose a large share of its most talented software engineers, particularly to the U.S.A. Migration of graduates from premier institutions like the IITs is estimated to be as high as 50 percent. India's limited pool of experienced software engineers is therefore threatened, and is unlikely to be replenished without substantial costs and delays. The Government, together with the industry, may explore various measures and strategies to stem, and perhaps reverse this flow. Measures to increase off-shore, rather than on-site software development may be a key element in such a strategy.

The Government's support for reorienting and deepening India's R&D infrastructure to respond to the special needs of the sector is also needed. Two broad options might be explored: a national R&D promotion fund, and a regional (or state) R&D program. The national fund would stimulate the demand of IT industries to use technology services institutions for R&D and provide loans to select technology institutions with promising R&D programs in informatics. This approach would build on the experience of the pilot programs developed under the Industrial Technology Development Project and would tailor appraisal and funding procedures to the special requirements of IT suppliers and users.

The other option is to focus on the technology infrastructure of the state of Karnataka, the "Silicon Valley" of India. This regional approach would build on the clustering of technological activities—which encourages close links between suppliers and users, competition and collaboration, and the development of shared facilities, staff, and other specialized and support infrastructure. An applied research center could be created to focus on advanced software engineering, computer sciences, and industrial electronics—and thus draw on existing Karnataka science and technology resources (e.g., IISC, NAL, ISRO, CFTRI, CMTI). The center could be privately managed, with its own staff as well as with staff from universities and other local R&D centers. It would also mobilize the R&D resources and funding of large IT suppliers and users--such as CMC, NIC, and TCS.

Data Communications Development

Because they are so urgent, the data communications needs of the software and information services industry should not await a full implementation of the long-term policy reform agenda for telecommunications. An important requirement for the increased participation of the Indian software companies in this global industry is the need for a 64 kilobyte or higher quality data communication link to reach international gateways for easy link-up with global markets and for ensuring on-line development and support services to overseas clients in a cost-effective manner. Availability of such cost-effective communication link-ups would enable Indian software companies to tap their clients' hardware resources through machine to machine connectivity. This is particularly relevant for the U.S. market, where the time

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difference with India is around 12 hours. Therefore, the Indian software exporter can log on to their clients' hardware during night time in the U.S. when the computers there are normally not in use. In this manner Indian software companies can access the latest hardware platforms and thus get around the problem of inadequate availability of such hardware in India. Perhaps as important, high-quality communications would improve quality and integrate software development and project management activities in India, and reduce both the psychological distance and the need to export software manpower for on-site services. This would substantially enhance the cost-competitiveness of Indian software services and enable providers to move up the technological ladder and enter into higher value added services.

Recent policy decisions to open up data communications to local and foreign investors are a major step towards improving these services. The Government may further explore various options, in collaboration with the private sector. One option is the immediate expansion of NICNET or an equivalent facility to become a truly national data communications facility, may provide immediate relief to priority data communication needs for such key users as software companies, district governments, and perhaps banks. It would also exploit the substantial databases and value-added services already developed by the NIC. Another option is to create a new autonomous data communications utility that would be owned by major users: banks and financial institutions, large private sector users, Government and perhaps a multinational telecommunications supplier. The utility would then be managed on a commercial basis. The regional initiative of the State of Maharashtra to establish a state-wide network should be encouraged, perhaps through government cofinancing and other incentives, in view of the demonstration effects of such a project. Many other options should also be explored by the private sector, and the Government can facilitate the process of innovation and private sector participation in data communication and value-added services by reducing risks, promoting competition, and perhaps providing seed capital.

Public Sector Modernization

The government has invested much in computerization over the years, but with mixed results. Three broad areas lend themselves to substantial improvements and high payoffs:

(a) Automating key large-scale transaction systems, such as tax administration, public expenditure, land records, and treasury management.

(b) Modernizing trade logistics systems, particularly ports and customs.

(c) Developing information systems to support policy analysis, program design, expenditure control and monitoring of priority national social programs.

Many public information systems are in urgent need of development. The Government may consider the following candidates for public information computerization: a legal information database to support the judiciary system, a system to make regulatory
information available to businesses, a system to capture and make trade information available to traders and exporters, and a system to capture and make available large databases on technologies and research results in various fields. In creating and maintaining such systems, the Government may consider various mechanisms to set priorities and to facilitate coordination within the public sector and collaboration with private associations and NGOs.

Another option for the Government to consider is to have a fund established and administered either by a steering committee, or a suitable government agency, to support increasing productivity in public services through better use of informatics. An inter-agency mechanism, or a suitable government agency, may be developed whereby proposals for major investment in IT application or in elements of a national information infrastructure would be systematically developed, prioritized, then acted upon. The development of specific applications should be open to bids from the private sector. The committee would establish priorities and criteria for funding, which would aim at promoting best practices in systems planning and implementation.

Given the difficulty of diffusing IT at lower levels of government, and the need to understand the institutional and human factors that influence the introduction and use of modern information systems, the Government may consider establishing a small national innovation fund—in support of the use of IT for human resources and rural development. This fund would mobilize public, private, and NGO resources for small projects and pilot programs that aim to:

(a) Expand rural access to relevant public information resources.
(b) Use packet radio and other low-cost facilities to improve communications among rural NGOs.
(c) Promote the employment of women in software development.
(d) Develop "expert systems" in support of medical diagnosis for rural health delivery.
(e) Develop databases and information resources centers in support of various extension services.
(f) Assist interested state governments in improving their information management practices through monitoring and evaluating pilot projects at the district level.

As the central MIS organization for the public sector, the National Informatics Center (Annex 4) could be a key force in promoting IT diffusion in the public sector. The NIC has been the government's central agent to bring computerization and modern communication and information to public agencies, but it lacks focus and transparency. The Government may consider building on the NIC's strengths in promoting business effectiveness and efficiency in government through the use of information and communication systems. Canada's Government Consulting and Audit Agency, Singapore's National Computer Board, and the U.K.'s
Government Center for Information Systems, are just a few examples of organizations supporting government in the use of informatics goods and services to improve public services.

The NIC should be subjected to fair competition in developing information and communication systems for the public sector, and it should increasingly rely on outsourcing or subcontracting with private software houses and develop business-like relationships with public users. Developing a coherent corporate strategy is perhaps the most urgent step for the NIC—to define its strengths and weaknesses, identify measures for institutional restructuring and development, and spell out its future role in public sector modernization.

One option for the NIC is to perform the following functions: (a) set standards and guidelines for information quality, security, procurement, and communication protocols among government agencies; (b) provide technical assistance to public agencies in information management, systems planning, and informatics procurement while they move toward self-sufficiency; (c) assist state governments in improving data collection processes and developing common databases and systems applications for key administrative functions; (d) promote experimentation, innovation, and sharing of best practices in information and technology management; (e) promote decentralization and access to information at lowest levels of government as well as information sharing across agencies; (f) perform a technology watch for the government; and (g) study, monitor and evaluate aggregate public investment planning, implementation, and use of information and information technology resources.

Financial Sector Modernization

The Government has recently attached a high priority to improving the performance of financial institutions, and the Minister of Finance has indicated the urgency of updating banking technology. In addition to the evident merits to the financial sector of improved information and communication systems, a well-designed national program could also provide a great boost to the development of a competitive domestic market for the information technology industry and services, and demonstration effects and externalities for other IT users. Although there are no simple or uniform solutions, the process of modernization may be accelerated through a variety of instruments that would induce the use of best practices, develop common systems applications, and invest in the corresponding institutional and human adjustment processes. Many possibilities may be explored to provide solid demonstration effects, have an early impact on financial services and stimulate vertical specialization of the software industry in banking applications.

Computerization programs of financial institutions in industrial and developing countries suggest that they should be well planned to yield full benefits. The key guidelines for such a program for India would be to:

(a) Ensure that automation plans are based on clear business priorities and strategies.
(b) Set performance standards and incentives for the introduction of IT.

(c) Engage top managers of each bank in setting and implementing the automation strategy, and in managing the associated behavioral changes.

(d) Provide training at all levels of management.

(e) Certify bank officers for proficiency in information systems and provide matching grants to cover training costs for those certified.

(f) Exploit common applications and promote open systems and functional standards among financial institutions.

(g) Improve online communications from the branches to central offices, among banks, and with the Reserve Bank of India.

(h) Develop strategic systems for supervision, accountability and policy analysis for the Reserve Bank of India and for corporate management of the commercial banks.

Software Industry Development and Diffusion

A competitive market—necessary for the use and diffusion of IT applications in the private sector, as well as for the development of a dynamic IT industry—may be complemented by national programs to help small and medium-size enterprises overcome information failures and R&D risks and to help small software companies overcome financial market failures, institutional rigidities and infrastructural constraints. The design of such programs should draw on the extensive experience of OECD and NIEs in designing and managing similar programs (Annex 5).56

Four main programs are suggested. First, various private intermediaries (software services companies, National Productivity Council, Confederation of Indian Industries, consultancy companies) could be mobilized to help small enterprises in key industries introduce proven application packages for common business problems. These may include application areas such as computer aided design (CAD), materials requirements planning (MRP), and business control (MRP II). Some intermediary and consulting institutions have begun to do so, but their reach is still very limited to the large enterprises, and pilot programs could extend their reach to the small users.

Second, the capabilities of selected financial intermediaries and their lending norms and procedures may be developed to deal with the special needs and risks of small software

56 Two studies by the World Bank are underway, one to review the experience of OECD countries and other, to review the strategies of NIEs in promoting IT development and diffusion.
houses. One option is for Government to provide facilities and pilot programs for specialized financial institutions to promote appropriate lines of credit tailored to the specific financial needs of the software industry. Clear guidelines should be also established for fast processing of applications. Another is to modify regulations for venture capital and company law to accommodate sweat equity, provide exit routes for venture capitalists, and eliminate other tax and policy disincentives in equity and risk financing to the software industry. The Reserve Bank of India, Ministry of Finance and financial institutions may examine the procedural and skill barriers to the implementation of those policies that are on the books but not practiced in lending to this infant industry. Third option is to provide incentives and facilities for national banks to build specialized capabilities, recruit or train loan officers who understand the business of software and have clear guidelines for lending working capital to software and information services firms.

The information requirements of the IT industry and the users of IT products and services are substantial, in view of the fast pace of technical change, multiplicity of standards, and growing complexity of solutions and services. These requirements are difficult to meet by most small and medium IT users and suppliers, especially in the absence of adequate information channels and infrastructures. The software and hardware industries may explore various solutions, perhaps by their associations and in collaboration with various national agencies and regional R&D institutions and universities. The Government may consider augmenting the resources of private associations such as NASSCOM to deliver state-of-the-art seminars, disseminate the surveys and technical papers produced by various public agencies on technological trends, and perhaps experiment with video-conferencing with foreign experts. Open university education in electronics, computer sciences and software engineering may provide an additional chancel to keep professionals up-to-date in a fast moving field.

Regarding software technology parks, which were intended to overcome infrastructural and procedural bottlenecks, specific improvements are needed. One option is to increase private sector participation in the design and management of these parks. This could ensure that shared facilities and services become responsive. Another, is to promote private sector financing of software parks and extend to them the same export facilities (simplified procedures, and export incentives) already offered to technology parks and other schemes that were sponsored by government agencies. A third option is to harmonize and coordinate the various Government schemes: Export Processing Zones, 100 percent Export-Oriented Unit Scheme, Electronic Hardware Technology Parks, and Software Technology Parks. Currently, certain schemes are under the Ministry of Commerce, others under the Ministry of Industry, and yet others are controlled by the DOE, with different procedures.

Perhaps, a study of India's experience so far, particularly with software technology parks, could lead to improvements in the decisions governing the planning, design, financing, operation and cost recovery of such schemes. As these parks already represent important infrastructural assets, measures to remove bureaucratic barriers and enhance marketing and access to these assets should be also systematically explored. For example, overseas telecommunications and hardware facilities of the parks could be made available through
electronic means, at appropriate fees, to software firms not residing physically at the park. Similarly, the park may be used as a focal local point for the delivery of a variety of national and regional services such as information, marketing, training, and other support services. The telecommunication facilities may also be used for distance learning, to expose the industry to international experts and state-of-the-art seminars.

Third, private sector associations and intermediaries could be mobilized to help software houses introduce quality and productivity programs, perhaps similar to those proven to be critical for sustained exports in OECD and NIEs. Government may consider other options to promote software quality (Box 5).

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**Box 5: Options to Promote Software Quality**

The Government may consider various incentives for software companies to get ISO 9000 certification. These may include:

(i) The Government may provide a certain sum as grant to companies attaining this certification.

(ii) The Government may subsidize the ISO 9000 consultancy and certification consultancy assistance costs (many Asian/South American countries are currently doing this).

(iii) Tax credit may be provided for ISO 9000 related expenses.

(iv) The Government may specify ISO 9000 Certification as a pre-requisite for certain benefits (like awards, recognitions, access to tender information, etc.)

(v) Certain government jobs or contracts may go only to ISO 9000 certified firms.

(vi) Special incentives for first 20 companies to get ISO 9003 certificates.

*Source: NASSCOM*

Fourth, a very promising program to promote export marketing and alliances between Indian and foreign software forms—supported by the Developing Countries Trade Agency—could be substantially expanded, perhaps with funding from bilateral and multilateral aid agencies (see Annex 7 for details). This program could also exploit the potential synergies between Nonresident Indians (NRI) knowledgeable about the global software market, and the local firms. The Government may further explore other options to improve overseas marketing (Box 6).

In all these programs, government role should be as a catalyst, to induce the use of private sector services to deliver business and technical support services to small and medium
enterprises, IT suppliers or users. Program design, even while addressing a specific market failure, should exploit market signals, for example, by ensuring that enterprises would pay

Box 6: Options to Improve Software Overseas Marketing

Availability of more finances for marketing. Software companies need to allocate a greater part of their budget to marketing of their products and services. This is especially important for the packaged software segment, where the packaging and marketing cost of the packaged software product may be as high as 70% of the list prices of the product.

Joint Ventures with IT Companies. Some product oriented companies can achieve a better and more secure return by forming a strategic alliance with a bigger international company such as hardware vendors, system integrators and independent software vendors with a complementary product range or another company selling different kinds of products into the same niche market. Such an alliance would give the Indian company access to an established worldwide distribution channel. The products may be sold under a third party label, but the financial returns will be greater and the need for additional capital reduced. Management expertise can be applied to the development process where the company has experience, rather than dissipated in export product marketing, where they may be novices. Alliances such as these are possible only for companies which have innovative products, are quality driven and confident in their ability to maintain a competitive advantage.

Acquiring companies abroad. Indian companies can take over companies abroad which have well known packages but have not done well due to ineffective management and inadequate resources.

Joint Ventures with End-Users. Joint ventures with large end users can be a major avenue for expanding exports. Marketing in this direction is economical and more suited to Indian conditions.

Diversification by Large Business Houses. Large business houses may be encouraged to diversify into software exports. These companies are strong in terms of available finance, market reach, etc.

Image Marketing. The recent efforts by Department of Electronics to arrange delegations and seminars abroad has had a visible impact on the awareness of India's potential as a software exporter. This needs to be arranged on a continuous basis in association with the industry.

Consortium Development. Another potentially useful initiative would be indigenous companies 'clustering' together for common objectives. This would allow companies with similar profiles to share resources and costs in certain key areas. For example, companies offering complementary products or services within a particular sector (for example, telecommunications, multimedia, health, aerospace or PC tools) could come together for marketing, training, or R&D purposes.

Another advantage of this would be a higher profile for their common sectoral area in dealing with the market and indeed with the state agencies. The companies could market themselves as a 'cluster' with more success than they could as individual companies. Also, the geographic concentration of software companies in India lends itself to the cluster concept.

Source: NASSCOM
appropriate share of the cost of the IT consultancy service. Such programs should be phased, pilot tested, and monitored to ensure learning from, and building on local experience.

Roles for Private Sector and Government

The various options and action programs proposed here suggest complementary roles for the private sector and the Government. The private sector is the primary beneficiary, especially those small and medium enterprises who are the main suppliers and potential users of IT and IT-based services. Public services and infrastructures given high priority for modernization would be those critical to reducing transaction costs for the private sector. Measures to improve quality, productivity, marketing and product development among software houses will be cost-shared with the private sector and delivered by local and international consultancy firms. Similarly, measures to diffuse best practices in IT investment and management would be carried out by the private consulting industry and trade associations. Private training institutions may be induced to improve quality and professional associations may be used to design and administer accreditation and quality enhancement programs. Thus, these proposals are designed to induce maximum response and participation from the private sector in the financing and implementation of a national IT strategy.

The recommended role for Government is to provide the enabling policies, incentives, infrastructures, and institutional mechanisms for IT suppliers and users in the private sector and to adopt best practices for IT investment and management for its own core functions. Specifically, the Government may consider three complementary roles:

- To develop policies for creating competitive markets in IT products and services and for investing (or inducing investment) in a data communication infrastructure, software manpower, and IT user education.

- To improve investment in and use of IT resources in public administration, and to target few large applications that would support export and private sector development, reduce transaction costs between public and private sectors, provide demonstration effects and create markets for software development and value-added services.

- To develop—in collaboration with private sector institutions—incentives, extension services, and other market-enhancing measures and programs to address specific market failures (and externalities) in the supply and diffusion of IT, particularly for small software firms and user enterprises.
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Annexes

Annex 1:  THE INFORMATION TECHNOLOGY REVOLUTION: INTERNATIONAL EXPERIENCE
Annex 2:  GOVERNMENT POLICIES AND STRATEGIES FOR THE SOFTWARE INDUSTRY
Annex 3:  SUPPLY-DEMAND ANALYSIS FOR COMPUTER (SOFTWARE) PERSONNEL
Annex 4:  MAIN INSTITUTIONS OF THE SOFTWARE INDUSTRY
Annex 5:  COUNTRY EXPERIENCES IN PROMOTING DIFFUSION OF IT
Annex 6:  JAPANESE AND SINGAPOREAN EXPERIENCES: COMPREHENSIVE STRATEGIES
Annex 7:  SOFTWARE EXPORT DEVELOPMENT FUND (SEDF)
The following application areas illustrate the pervasive and strategic impact of informatics on industries, services and public sector management.

**Industries**

Information technology has two broad implications for the industrial sector. The first is creating new industries through new microelectronic or software based products and the blending of IT with other technologies. Currently, the IT industry is the fastest growing global industry. The combined business of computer hardware, telecommunications, software and related support services already exceed one trillion dollars. The growth prospects and high profitability of these "high technology" industries, and perhaps more important, the strategic importance of the core technological competencies associated with producing and applying IT, have attracted the attention of both industrial and developing countries.

The second is the use of IT in processes and industrial organization, for productivity and value added enhancement (miniaturization, factory and office automation, industrial process control, microelectronics in automobiles). IT is also extensively applied to reduce transaction and coordination costs in product design, manufacturing, and marketing activities, within and across firms (Just-in-time, customization, Total Quality Management, Flexible Manufacturing Systems, global outsourcing, integration among functions, network organization).\(^5\)

The second type of application is perhaps the more important, yet the less appreciated, especially among developing countries. Information technology has been perceived by OECD countries as a major opportunity to modernize traditional "low tech" industries such as textiles, apparel, and footwear as well as revitalize core industries such as automotive and capital goods. Emerging empirical evidence also suggests that IT can help to blend traditional industrial structures, based on small firms, with trends towards quality enhancement and market segmentation both in consumer and capital goods.\(^6\) In this sense, information technology is an "enabling" technology, mastering its use generates externalities throughout the economy.

Empirical studies suggest the profound implications of IT-based product design and manufacturing on the competitiveness of key industries in developing countries. For example, the advantages gained by users of computer numerical controlled (CNC) machine tools are such that the market for conventional capital goods produced by developing countries is


\(^6\) See, for example, C. Antonelli, "New Information Technology and Industrial Organization - Experiences and Trends in Italy", in Information Technology and New Growth Opportunities, OECD, 1989.
declining. The impact of IT on the clothing industry has also been dramatic in terms of quality and responsiveness to market, and may have halted further migration of this industry to developing countries. The organization and economics of automobile assembly have been transformed by exploiting IT-based systems in product development and engineering, procurement and supplier integration, flexible manufacturing, and distribution and marketing. The unit cost, quality and lead time advantages gained from the adoption of these technological and managerial innovations are so substantial that most other OECD-based manufacturers, and increasingly the NICs, are being forced to adopt similar practices in order to survive.

Mass production which has dominated industrialization in the twentieth century is being replaced by "lean production" methods, which are highly information- and communication-intensive. These methods are spreading among industries and very un-evenly, across countries. In general, these techniques are characterized by increasing levels of total factor productivity because of reductions in working capital (all types of inventory) and in the idleness of physical assets (through flexible and integrated manufacturing, maintenance control, management information systems).

Information technology diffusion is influencing the flow of foreign investment and trade, as it changes both the production and governance functions, particularly of the multinationals. It tends to induce decentralization and specialization of the production function, by lowering the minimum efficient size of production units. At the same time, it tends to increase quasi-integration, economies of scope, and the size of the governance structure, by reducing the costs of coordination and control. Among the salient effects of such a conflicting mix of centrifugal and centripetal forces are: increased access to multi-sourcing; globalizing the procurement function; foot loose location of new plants; niche strategy based on differentiation; electronic subcontracting; on-line reinforcement of quality control of subcontractors; increased coordination between engineering, manufacturing and marketing; accelerated product life cycle; reduced delivery time; and strengthened financial controls and corporate management systems. The overall result of such forces, generated by the introduction of IT, is a growing trend towards developing a new form of organization, called the network organization.57

Although there are examples of advanced and effective uses of computing and communication technologies in industries in developing countries such as India and Brazil, the examples tend to be limited to a few large firms and to have little downstream linkages with local suppliers and the rest of the industrial sector. Moreover, unlike OECD countries, there is limited information available locally on the opportunities and pitfalls of IT adoption, underdeveloped local consulting and specialized providers in IT applications to manufacturing, and hardly any government programs to promote or facilitate the introduction and diffusion of such applications. Some of the NICs, such as Taiwan, Singapore and Korea, provide some exceptional examples.

Information technology is profoundly changing producer and consumer services in industrialized countries, by transforming the organization and processes of existing service sectors and by creating new services industries. It has fundamentally increased the options for customization of services even while taking advantage of economies of scale and scope. When appropriately applied, it empowers "contact" staff with substantial information resources to respond to customers. In the process, IT often disintermediate costly organizational bureaucracies, support rapid execution of strategies and substantially increase responsiveness. These fundamental process and organizational changes are progressing across all types of services: trade, distribution, transport, marketing, insurance, financial services, engineering and other professional services, etc. 58

Changes in service technologies have major implications for developing countries. Producer services have become critical to industrial competitiveness. The role of services in the globalization of competition has forced large manufacturers to consider their supply sources, markets and finance on a worldwide scale. Informatics is also globalizing the services industries themselves and has substantially increased international trade in services. These trends are perhaps most pronounced in the financial services.

Logistics provide an interesting example of the strategic implications for developing countries of IT-induced changes in services. 59 It became possible to closely monitor all phases of moving a product from its raw material source through all intermediate processing stages to the final consumer. Meantime, the consumer has become more informed and demanding. Business practices are thus changing in fundamental ways and placing even more stringent requirements for reliable deliveries in increasingly shorter time intervals and with low reject rates. These requirements reflect the growing practice in international trading to acquire and produce goods in close relations with fast changing market demand. A new management approach, called "logistics management" has emerged to orchestrate the functions of materials acquisition, production, transport, warehousing, marketing and other support services. The application of logistics management practices have enabled many industries and trading organizations to conduct their business with inventories often less than one week of required supplies. As these practices are becoming pervasive in OECD markets they are likely to dictate much of the future participation of developing countries in trade and manufacturing (as more than 80 percent of exports from developing countries are targeted for OECD markets).

The impact of IT in services has been uneven, however, both within and across services. This is the case in the most computerized services in the industrial countries, i.e. the


financial sector. Studies of computerization in banking in OECD countries suggest that IT, together with deregulation and internationalization of financial service markets, are promoting a radical shift in the functional emphasis of banks: away from the production of services (back-office functions) and towards sales, customer assistance and product development (front-office functions). Shifting to these new functions demands a fundamental reorganization in the division of labor and a new emphasis on decentralization of functions and decision making. The result is the need for a radical shift in the organization's human resources, involving a widespread upskilling of the firm's entire labor force and an emphasis on a new array of skills focusing particularly on customer assistance, entrepreneurship, and high level professional and managerial expertise. Studies of banking computerization in developing countries further reinforce that the realization of productivity and quality improvements (anticipated from computerization) is heavily dependent on the quality of management and human resources of banks. In most developing countries, including India, even the production (back office) functions still have substantial productivity gains to be realized, from "straightforward" automation.

Advances in IT have driven the rapid growth of a relatively new services sector, the information services. Technological change has increased capacity for data capturing and organization, generated new media for data storage and transmission, and integrated various media and sources of information. It has induced horizontal integration across broadcasting, publishing, on-line databases and other information services. It has led to the emergence of multi-media and global information companies. These developments are already having profound impact on education, consumer behavior, democracy, and quality of life in OECD countries.

An emerging application of information technology is to mobilize and disseminate public data. The public sector, in both industrialized and developing countries, is the major collector and investor of data on all types of economic and social activities and natural and demographic resources. The dissemination of public information resources is a key to competitive markets. A growing private information industry can add value to these resources and tailor them to the specialized needs of clients. Governments are recognizing the strategic importance of their information resources in competing in a global information-intensive economy. Most OECD countries have adopted policies to expand private access to public data, to improve and harmonize data standards, and to promote a competitive market in information services. These trends are critical to developing countries, both in terms of access to global knowledge and international data bases, and new options to mobilize and use their own local knowledge and information resources.

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60 See, for example, O. Bertrand and T. Noyelle, Human Resources and Corporate Strategy: Technological changes in Banks and Insurance Companies, OECD, 1988.

Public Sector Management

Public administration is by its very nature highly information intensive and transaction driven. Not surprisingly, mainframe computers were first used in the public sector, and until now, public administration remains the largest investor in information and communication systems in almost all countries. OECD countries continue to invest in the computerization of social security, tax administration, customs, public procurement, financial and personal management, budget and treasury management, patent records, ports, aviation, and many large transaction systems. Most of these applications have become essential to public administration and the running of government. They support internal management functions and the automation of existing services to increase efficiency and contain the growth of the civil service.

During the 80s, the advent of microcomputers and electronic networks has substantially expanded the opportunities to apply IT in public sector management. These applications are intensifying the use of information for policy making, planning and budgeting, monitoring service standards, delivery of new services, and accountability and control.

The benefits from such applications are substantial but not automatic. Experience in industrial countries, where these applications are most advanced, suggests that the full benefit of IT is achieved only when an organization applies it to informating (analysis) in addition to automating (processing). It also suggests that "automating" applications demand minimal organizational reform. In contrast, informating, or the use of information in decision making, requires new skills and extensive organizational changes.

Many developing countries are automating their critical transaction systems such as the national budget, tax administration, and treasury management. The challenge is to begin to use information systems applications to support planning and decision making, to improve coordination, to facilitate decentralization and accountability, to provide superior extension and support services, and in general, to improve the quality of policy and program management. Realizing the full benefits from these applications require new levels of training and motivation currently uncommon in development bureaucracies.

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62 S. Zuboff (1985,88). Strassmann (1985) also makes the distinction between the "efficiency " and "effectiveness" payoff of IT, which is analogous to the "automating" and "informating" roles defined by Zuboff. Efficiency is accelerating existing work, whereas effectiveness is changing the nature of work.

GOVERNMENT POLICIES AND STRATEGIES FOR THE SOFTWARE INDUSTRY

Plans vs. Performance

The Indian government has repeatedly set software export goals that have either been based on the limited but alluring data available on the "world" software market, such as when it announced the Computer Policy Plan in November 1984 and expected software exports to reach US$258 million (or 0.5 percent of the world market) by 1990, or more recently when it set targets of US$400 million and US$800 million by 1992 and 1995 respectively. Figure 1 contrasts actual exports with export targets set in 1986.

Having set these goals, policy making and implementation have fundamentally focused on ways to make export figures rise. The institutional framework for the export of software has serious weaknesses—for example, troublesome delays exist for import of computers and spare parts, local communications links are poor, gaps remain in the financing services for exports, high export commitments must be made to import foreign hardware, etc. On the positive side, it has pushed firms into exporting. On the negative side, this pushing has been short-term oriented and without any specific focus or direction on building sustainable competitive advantage and capabilities.

Improving Exports and Earning Foreign Exchange: Processing Zones and Software Technology Parks

The government has provided a nurturing and supportive environment through the establishment of the export processing zones and software technology parks (STPs), to encourage companies to export mainly labor-intensive light manufacturing, garments, and electronic goods. The Bombay-based zone is of greatest relevance to software. Based near Bombay’s international airport, SEEPZ (Santa Cruz Electronics Export Processing Zone) was set up solely for the export of electronics-related goods, and has until recently retained this focus. There are six operational zones, although SEEPZ, NOIDA near New Delhi, and MEPZ in Madras account for most exports in electronics and software. There are several policy incentives and facilities that attract local Indian software firms and foreign collaborations in these zones. The main ones include: fast, duty-free import and export; wholly-owned foreign firms are allowed and can repatriate profits; single ‘window’ clearance for all bureaucratic dealings with the government; exemptions and subsidies on sales and excise tax, rent, power and water; a 5-year tax holiday; and 25% of production can be sold by firms into the domestic tariff area, which gives them a competitive edge over other imports. In performance terms, software companies with foreign collaborations and with heavy investments in imports, have done well, and outperformed the purely domestic units.

To provide small and medium scale firms an opportunity to enter the international software export market, the DOE has established a number of STPs throughout India. The
major objectives of the STPs are:

(a) to establish and manage infrastructural resources and provide service to users for the development and export of software;

(b) to undertake export promotion activities;

(c) to train professionals in the field of software technology; and

(d) to improve design and development of software within the STPs.

These objectives are to be achieved by setting up 15 STPs throughout the country. Currently, the DOE has established 7 STPs in Pune (August 1990), Bangalore (October 1990), Bhubaneshwer (December 1990), Hyderabad (February 1991), Thiruvananthapuram (July 1991), Gandhinagar (July 1991), and Noida (July 1991). Additional STPs may be set up in Jaipur, Calcutta and Mohali. Approximately 160 companies have been approved by the DOE to participate in the STP program. The estimated software exports of these companies is US $7.28 million by 1994. As the STPs in India are still in the initial stages of development, it may be too early to judge whether these parks would live up to expectations and be effectively managed.

Intellectual Property Protection

Software piracy has forced some software companies out of the domestic packaged software market, such as Wipro Systems Ltd., and is likely to force others out soon. The magnitude of the problem is illustrated by an estimate from Lotus Development Corporation, that of the 150,000 copies of 1-2-3 in India, 140,000 have been pirated. Companies that developed microcomputer-based products for wordprocessing, database management, and accounting that were more or less functional equivalents to dBase, WordStar, and Lotus, found selling their products in India practically impossible since these internationally popular programs were available for the cost of a package of diskettes.

The national software industry has until recently been ambivalent about demanding protection of software. Some progress has been made toward educating end-users about the need to guarantee intellectual property rights by purchasing and registering software. These have taken the form of advertisements and a few educational programs. Still, no successful action has been taken under the copyright law, and the government, software houses, and the national industry association seem unwilling to launch an action to test the anti-piracy laws. The impact of these advertisements and campaigns therefore remains questionable.
Foreign Collaboration

The Indian informatics sector in general and the software industry in particular have only "mildly" cooperated with foreign firms to obtain technology and investment. This attitude has changed over the years, and 100% foreign equity holdings have been permitted since 1986 in export oriented projects, but only 40% foreign equity is allowed for companies producing software for the domestic market. In electronics, some of the special measures and approvals that Texas Instruments (TI) obtained from the government have helped make India more attractive to other foreign firms such as Hewlett Packard, DEC, British Telecom, Phillips and Westinghouse. For example, TI obtained a private Intelsat Business Service earth station so that its programmers can communicate with other TI operations using satellite links. Foreign investment has been attracted by the availability of skilled labor, relatively low wages, and a desire to keep a foot in the domestic market.

But given the increasing shortcomings of qualified and skilled software engineers, the large investments in imported equipment to carry out offshore work, costly bureaucratic procedures, and the negligible amount of foreign investment of these foreign firms compared to similar investments in Hong Kong, Taiwan, and Singapore, it would appear that foreign firms remain in India mostly in hopes of being able to sell a proportion of their output in the domestic market and for a future base in South-East Asia.

The window may fast be closing on India’s opportunities as an off-shore software developer for multinational corporations or for U.S. and European companies with large information systems departments. According to Hewlett Packard, China and Central Europe (e.g., Hungary) are now cheaper sources for both location costs as well as salaries for programmers. Further, the quality and availability of skilled software professionals are becoming more important to multinational firms than labor costs. The orientation of the sector toward renting out programmers for the export market has led to the ubiquitous problem of "brain drain" in terms of programmers as well as shortages of teaching staff. Nearly 60% of IIT Bombay and Madras graduates in computer science leave the country for continuing studies or jobs overseas. It is also important to take note of the impact the "push on exports" has on other sectors of the economy, since as noted earlier there is considerable cross-linkage between software and other sectors. It is estimated that software export needs could "cannibalize" other sectors by taking almost one-half of all new computing course graduates from government-initiated courses. The focus on onsite programming services in export work has resulted in a self-reinforcing process, with analysts lost to foreign companies or never developed.
Figure 1: Growth Rates of Indian Export Software Industry

C.A.G.R. in Rs = 54.31%
C.A.G.R. in US$ = 34%
**Figure 2: I.T. Industry in India, 1985-1991**

(all figures in million)

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<td><strong>Total</strong></td>
<td>1000</td>
<td>81</td>
<td>1400</td>
<td>108</td>
<td>1750</td>
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<tr>
<td><strong>Maintenance</strong></td>
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<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>Others</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>Grand Total</strong></td>
<td>3490</td>
<td>281</td>
<td>4830</td>
<td>369</td>
<td>6540</td>
<td>484</td>
</tr>
</tbody>
</table>

C.A. G.R. for I.T. Industry = 43.45%
Figure 3: Growth Rate of Indian Domestic Software Industry

SUPPLY-DEMAND ANALYSIS FOR COMPUTER (SOFTWARE) PERSONNEL

Very rough estimates have been made from the available data on the demand and supply for different types and categories of job. However, these estimates have to be treated with caution and should be considered as orders of magnitude only. Table 1 below shows estimates of the demand by types and categories of jobs for the Eight's Five-Year Plan period. The data is particularly speculative regarding the demand for programming professionals in the non-computer industries and services sectors since there is very little data available for these sectors.

Analysis (Annex 3, Table 1) indicates that demand in computer applications industries is very large and expected to grow rapidly. This demand includes domestic railways, banks, steel, coal, electrical and machine tools and automobile industries that are in various stages of automating their operations. The categories of software specialists these firms require most are programmers and system analysts. Of these two categories, system analysts are more difficult to get. Usually they are produced through in-house training of engineers and business graduates, with interest and aptitude for computers, often already employed by the firms. Some of these seek training outside the firm in public or private training institutes. The majority however are trained in-house. For these, the training costs are high and training programs are time consuming and difficult to organize. The other category of personnel for which there is a high and growing demand is that of software engineers. At this time there is no long-term formal training program for software engineers in India. Some of the software companies (e.g., TCS) are looking for ways of establishing such a program because of a severe shortage of software engineers.

The estimated supply of the five categories of software personnel may be estimated from the three major sources of trained personnel: public sector education institutes; private sector training organizations; and in-house (on-the-job) training operations (Annex 3, Table 2). The supply data is rather inaccurate even for the public sector. However, it is clear that there is hardly any supply of software engineers and that the supply of system analysts is restricted to the in-house training done mostly by firms. It is also clear that there is a relatively small supply of entry level data-entry personnel.
<table>
<thead>
<tr>
<th>Type of Industry</th>
<th>Year</th>
<th>Computer Hardware Firms</th>
<th>Computer Software Firms</th>
<th>Computer Applic. Firms</th>
<th>Total by Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Entry</td>
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<td>52,500</td>
</tr>
<tr>
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<td>1992</td>
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<td>-</td>
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<td>53,000</td>
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<tr>
<td></td>
<td>1993</td>
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<td>-</td>
<td>50,000</td>
<td>53,500</td>
</tr>
<tr>
<td></td>
<td>1994</td>
<td>3,500</td>
<td>-</td>
<td>50,000</td>
<td>54,000</td>
</tr>
<tr>
<td></td>
<td>1995</td>
<td>4,000</td>
<td>-</td>
<td>50,000</td>
<td>54,000</td>
</tr>
<tr>
<td>Programmers</td>
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<td>20,000</td>
<td>24,000</td>
</tr>
<tr>
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<td></td>
<td>1993</td>
<td>3,000</td>
<td>1,000</td>
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<td></td>
<td>1994</td>
<td>3,500</td>
<td>1,200</td>
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<td>Software Engineer</td>
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<tr>
<td></td>
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<td>1991</td>
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<td></td>
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<tr>
<td></td>
<td>1995</td>
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<td>400</td>
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</table>
## Table 2: Estimated Supply of Computer Personnel by Major Source of Supply, 1991-1995

<table>
<thead>
<tr>
<th>Training Program/ Category of Job</th>
<th>Year</th>
<th>Public Sector</th>
<th>Private Sector</th>
<th>In-house</th>
<th>Total by Category</th>
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<tr>
<td>ITI/Data Entry</td>
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<td></td>
<td></td>
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<td></td>
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<tr>
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<td>1991</td>
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<tr>
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<td>1995</td>
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<td>40,500</td>
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<td>DCA/Programmer</td>
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<td>Software Engineer</td>
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<tr>
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<td>1995</td>
<td>-</td>
<td>-</td>
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<td>Project Manager</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>1991</td>
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<td>50</td>
<td>500</td>
<td>550</td>
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<td></td>
<td>1995</td>
<td>-</td>
<td>200</td>
<td>800</td>
<td>1,000</td>
</tr>
</tbody>
</table>
MAIN INSTITUTIONS OF THE SOFTWARE INDUSTRY

NASSCOM

The National Association of Software and Service Companies (NASSCOM) was created in 1988, with the mission of promoting, developing, and protecting the interests of the software industry. Its initial objective was to interact closely with the GOI to formulate national IT policies with a specific focus on computer software. It has grown to become an active international industry association, and a key player in applying intellectual property protection to software. NASSCOM's 150 members represent 90% of the revenue of the software industry. Working with the Department of Electronics and the Electronics and Computer Software Export Promotion Council, NASSCOM has helped arrange several delegations and seminars abroad and in India to help create an awareness of India's potential as a software exporter. Projected operations will be in three major areas: (a) expanding software exports and establishing joint ventures, particularly with European companies; (b) promoting the domestic software industry; and, (c) seeking multiple forms of protection against software piracy.

National Informatics Center (NIC)

The National Informatics Center, established in 1986, is now an autonomous agency under the Planning Commission. NIC is headed by Dr. N. Seshagiri, its founder, who is well known as the architect of the computer and software liberalization policies in India when he was with the DOE. NIC nurtures the development of management information systems and the introduction of information technology in government departments. With a highly qualified and motivated technical staff that includes over 2000 engineers (of which 1000 have masters degrees or more), NIC has created a critical mass of informatics expertise, and has clearly demonstrated its ability to identify and develop automated information systems, as well as to devise suitable technology to implement these systems and to carry through the difficult tasks of putting them into operation and getting the necessary acceptance from users. Among other things, NIC has: (a) developed an internationally acclaimed and comparatively large satellite based communication network (NICNET) with more than 500 user terminals connected to modern, low-cost receiving terminals at user premises in district, state, and national government offices; (b) created more than 350 medium and large databases that are available through NICNET; (c) developed some 100 software packages for high volume transactions, district planning, and computer-aided design/computer-aided manufacturing (CAD/CAM); and (d) trained over 10,000 central government civil servants in hands-on courses related to the use of IT and data communications.

In certain respects, the sustained public investment in a central center like NIC is now beginning to pay off. NIC has gained considerable experience in dealing with systemic issues of requirements planning, procurement, and broader computerization objectives. It has a vibrant pool of IT specialists with domain knowledge of various industry sectors. NIC has also found innovative ways to take advantage of the latest generation computer architecture for centralized data control, distributed processing, and computer-aided instruction. Through its
training to civil servants, which is spreading to state and district officers, NIC is well-positioned and familiar with the management culture within government that is often resistant to technological change.

DOE/Software Development Division

The DOE has recognized the importance of information technology—not only for its direct contribution to industrial output and employment, but also as a source of productivity improvements in manufacturing and other sectors. It has singled out this sector for policy changes and infrastructure improvements to achieve efficient growth. A major reform in computer software followed the adoption in December 1986 of the Policy on Computer Software Export, Software Development and Training. Incremental improvements have continued to be made since then. Software has also benefitted from the investments DOE has made in Software Technology Parks (STPs), and a software technology research center in Bombay. Currently, the DOE has established 7 STPs since August 1990. Eight additional STPs are planned, and 160 companies have been approved to participate in the STP program, which provides building space, communication infrastructure, modern hardware equipment, and a "single window" approach for Government clearances of imported equipment. In addition, a technical assistance component of the Electronics Industry Development Project finances an international marketing study carried out by international consultants in close consultation with the DOE's Software Development Division and the Bank which suggests several new approaches to expanding Indian software exports.

Electronics and Computer Software Export Promotion Council (ESC)

ESC, a nodal agency sponsored by the Ministry of Commerce, was established to promote the export of electronics and software. Institutionally, ESC acts as a link between the government and exporters, providing consultancy services to individual companies with export potential, and drafting promotion schemes and operating guidelines for the government. Through many software export initiatives, ESC has encouraged the building of a market position for Indian firms through long term marriages rather than one-off contracts. The Ministry recently identified certain "extreme focus" sectors that could achieve at least 30% export growth annually over the next three years, and gave ESC responsibility for formulating a strategy to achieve this growth in the software subsector.


COUNTRY EXPERIENCES IN PROMOTING DIFFUSION OF INFORMATION TECHNOLOGY (MICROELECTRONICS IN INDUSTRIAL APPLICATIONS)\textsuperscript{66}

National programs designed specifically to increase the rate of industrial diffusion of microelectronic technologies have been implemented in a number of OECD countries. There are some common elements among them. The nature and focus of individual programs are determined by conditions such as the national industrial structure and market size, infrastructure and administrative capabilities, and government assessment of whether, and how, government programs can compensate for structural weaknesses and firm-level obstacles to more rapid and widespread applications.

National programs to increase the diffusion of IT in industry have been introduced for four principle reasons:

- To compensate for deficiencies in the economic/industrial environment, for example, an inhibiting size structure and industrial distribution of firms, weak links between suppliers and users of equipment, reliance on imported equipment or components;
- To strengthen the technological infrastructure that facilitates the transfer of technology from the developer or supplier to the user;
- To tackle specific firm-level obstacles to diffusion of technology such as low awareness and lack of skills; and
- To increase the supply of technical and managerial personnel.

Objectives of National Programs

The rationale for national diffusion programs is based on four underlying assumptions:

- Rapid diffusion of information technologies is essential for industrial competitiveness. Failing to keep up with or stay ahead of design and production capabilities of competing firms in other countries threatens loss of markets, dependence on foreign suppliers, poorer economic performance, and loss of employment;
- Many firms (particularly small firms) do not have the necessary technical and

\textsuperscript{66} Adapted from research by OECD (1989).
managerial capacity, financial capabilities or information to achieve rapid uptake of new technologies;

- The domestic technological infrastructure is not sufficiently strong to assure rapid diffusion; and

- Government assistance can be an important tool to increase diffusion.

The common objectives or outputs are summarized in table 1 below.

<table>
<thead>
<tr>
<th>Table 1: Objectives/Outputs of National Microelectronics Programs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Accelerate/increase diffusion of microelectronics technologies to manufacturing firms.</td>
</tr>
<tr>
<td>2. Increase investment in microelectronics technologies by suppliers and support firms serving manufacturing industry.</td>
</tr>
<tr>
<td>3. Increase sales of products incorporating microelectronics or of products/services using microelectronics production technology.</td>
</tr>
<tr>
<td>4. Develop a more technologically skilled work force.</td>
</tr>
<tr>
<td>5. Improve employment/labor mobility.</td>
</tr>
<tr>
<td>6. Strengthen the technological infrastructure:</td>
</tr>
<tr>
<td>- Consultants/diffusion agents/industry associations</td>
</tr>
<tr>
<td>- Technology institutions</td>
</tr>
<tr>
<td>- Training programs</td>
</tr>
<tr>
<td>- Education programs</td>
</tr>
<tr>
<td>- Academic/institutional research</td>
</tr>
<tr>
<td>- Government/institutional capacity to deal with technology issues</td>
</tr>
<tr>
<td>- Co-operation between enterprises and development/diffusion agents.</td>
</tr>
<tr>
<td>7. Government more responsive to technology diffusion.</td>
</tr>
</tbody>
</table>

The main activities covered in these national programs are summarized in tables 2 and 3. Table 2 suggests that these programs differentiate between the needs of small and large enterprises. Table 3 indicates those activities most emphasized in most OECD countries. The following briefly describe examples of these activities.
Program Delivery Activities

The ten types of diffusion support activities discussed in this section are included most frequently in the national IT diffusion programs examined.

Awareness activities. Awareness activities at an early stage of technology diffusion are designed to alert potential user firms to the scope and capabilities of IT - in new and improved products and in production and the organization of production. Funds are often provided to professional societies and industry organizations to run seminars, workshops, and conferences and to set up information centers and data bases to increase awareness of the wide scope of applications. Targets are often the small manufacturing firm where management may have a limited technical background. Demonstration projects towards the end of programs are very useful tools for spreading information on practical and technical results of applications.

Consultancy assistance. Programs in Denmark, France, and the UK subsidize the cost of firms engaging consultants to explore new applications of microelectronics in their products and/or production processes. Typically, an independent consultant prepares a written technical investigation indicating alternatives available, relative costs and merits of each, and the ultimate feasibility of applications.

Consultancy may be obtained from technological institutes specializing in that field (Denmark, Sweden) or from private consultants (France, UK). In the UK, the firms may go to one of approximately 300 authorized private consultants and receive the first two days consulting and 75 per cent of the remainder up to £2 500 , to enable initial feasibility studies to be carried out. In the German scheme about one-fifth of applications projects themselves were contracted to consultants rather than being carried out in-house.

Market identification, exploration and development. A major difficulty for many small companies is to determine the market for new goods and services. A number of program reviews have identified market exploration and development as a particular problem even when technical success is assured. Denmark is among the countries increasing the information and assistance available for exploration of export markets. Sweden is funding exploration of inter-firm markets, contracting and sub-contracting arrangements. To be successful, market development assistance must be delivered in a flexible manner, adaptable to changing market conditions.

Process development/process applications support. Denmark, France, Germany, Sweden, and the UK have programs that provide development funds to individual firms or to consortia of firms to develop microelectronics-based production processes. Support takes a variety of forms including grants, repayable loans, or project equity participation. In addition the program may encourage managerial and technical assistance from government laboratories or technology centers (Japan is a notable example) and in some cases general supporting research is undertaken. In France, the MECA scheme subsidizes purchases of advanced technology such as computer-aided manufacturing systems, provided that they represent a significant
technological advance for the firm. In Denmark and Sweden new process developments are supported provided that they are also used for demonstration purposes. The programs serve as facilitating mechanisms, helping firms to work with technological institutions and work together to develop new processes.

**Product development support.** Product development support usually goes to individual firms, and is often directed to start-up firms. In Germany and the UK government assistance is intended to assist the firm in going from the idea stage to the commercialization stage, at which point other financial sources, for example venture capital investors, can provide funding. Assistance ideally goes to projects which would otherwise not be funded, or be funded at lower levels or over much longer periods without assistance (the "additionality" principle). In Denmark the aid for product applications is also aimed at helping to commercialize new developments.

**Enabling infrastructure.** Government actions to build and maintain the technological infrastructure vary widely between countries. The overall government strategy for the infrastructure will depend on what is available: on the technical strengths of firms, private consultants, and technology suppliers, the availability of new technologies, and the industrial institutional structure. Private consultants and commercial technology suppliers are important parts of the infrastructure, as are the links between small and large firms (very important in maintaining Japan’s competitiveness). In some countries trade unions have also a potentially important role in spreading awareness and raising skills of employees, particularly where special training funds are established through collective bargaining, and where technology agreements aim to promote effective implementation of new technologies.

In Denmark and Sweden, the networks of private, non-profit, self-owned technological institutes are important elements in the diffusion of technology. The institutes are an extensive source of know-how for industry by carrying out research and development, consulting, technical and managerial training, testing and the development of testing methods, technology search and awareness activities. Roughly one-quarter to one-third of the institutes’ budgets come from the national government. The remainder comes from sale of client services. These networks include smaller, decentralized units and information centers, often working on a referral basis to supply information, contacts, and initial suggestions for further work to be carried out by, for example, the fee-charging technological institutes, authorized consultants, universities, or technical institutions.

**Technology supply.** Programs have aimed at improving the capabilities and building strengths of domestic firms in key fields such as design, development and applications of microelectronic components and creating a technology supply base more closely linked to domestic industry, and more responsive to its changing needs. Improvement of domestic capabilities to produce and use microelectronic components is the prime objective of Sweden’s national IT program. Increased domestic production of microelectronics, particularly integrated circuits, has been an important national objective of supply-side programs in other countries including France, Germany, Japan and the UK.
Technology diffusion can also be enhanced by improving access to all suppliers of technology, by seeking out foreign technology and adapting and applying it to local industrial conditions. Denmark's national program has specifically adopted this approach. It provides support for staff from technological institutes and from private industry to travel abroad and for foreign experts to visit Denmark, to improve knowledge of the technologies which are potentially applicable to Danish industry.

**Training programs.** The development of market-oriented short-term training programs have been notable features of diffusion programs in Denmark, France, Japan and the UK. These concentrate on the development of training courses for the existing managerial and technical workforce. Courses are tailored to meet the needs of specific firms or branches of manufacturing. Universities, technical institutes and private organizations have been funded to develop effective courses. Program officials do not develop course content - a task governments do not appear well equipped to handle. In most cases course development and training equipment is subsidized, but course attendance is not subsidized. The strategy has generally been to develop a decentralized market-driven process, aiming to efficiently supplement in-firm training and experience.

**Broad education programs.** Because of the shortage of skilled people to develop and apply IT, there have been many initiatives to broaden general educational exposure to information technology. Most countries have introduced a mix of general education in the use and potential IT, and more specialized education in microelectronics and software applications, design, and development. Secondary and adult education systems have concentrated on awareness and exposure activities (for example, training in the basic use of computer applications for design and production). Tertiary places have been expanded greatly in areas related to information systems and microelectronics, and applications of IT are increasingly part of more general technically-oriented courses (for example in controlling and monitoring functions).

**Support for basic research.** Some basic research by universities, technical institutes and industrial research laboratories is essential for the sustained diffusion of new technologies, regardless of the size of the country and the sophistication of its research base relative to other countries. Research is needed to:

- Develop ideas that eventually will result in new products and processes or new applications of existing technology;
- Develop technologically skilled manpower that can assess technology developments and manage applications in industry, consulting or government service;
- Encourage industry to invest in new technologies developed domestically or abroad.
Government funding is required to support much of this research. Although basic research support is often not a part of diffusion programs, it is an essential complement and even small OECD countries with limited research facilities and capabilities make such investments.

Funding of basic research has been a major element of US efforts to facilitate diffusion. But other countries, for example Sweden, have sponsored relatively extensive fundamental research activities specifically intended to promote microelectronics application and diffusion. A vigorous domestic research capability, whether administered in the framework of the diffusion program, or outside of it, is an essential adjunct to widespread diffusion - particularly if research activities has a strong market and applications orientation.

Planning, Implementation and Assessment of Diffusion Programs

Planning for the national diffusion programs require partnership between government and industry. In Sweden and Denmark, for example, committees of government officials and representatives from business and industry associations, technology suppliers, organized labor and the academic community are involved in the design of such programs. The design is based on systematic assessment of domestic supply capabilities and areas of industrial weaknesses (application needs). The importance of different types of support activities changes over time as users become more aware and the infrastructure more responsive. Awareness activities and widespread consultancy are crucial in the early stages of diffusion, while manpower development and adaptive research are of continuing importance.

A key decision is where to target assistance to realize maximum impacts: by industrial sector, firm size or other criteria. Programs in France, Germany, Denmark, Sweden, Portugal, UK and Japan gave priority to small and medium-sized enterprises. The German programs targeted smaller firms in machinery industries, where German firms have been traditionally competitive and where the challenges of new competition and IT applications are most keenly felt. But larger firms and more traditional industries are sometimes assisted to modernize and transform if they are slow to adopt IT on their own, particularly due to structural constraints.

Another lesson is to use existing institutions and associations and to ensure ease of application (e.g. for consultancy assistance), rapid decision making, and clear requirements and criteria. Extensive involvement of private or non-government in planning and delivering diffusion initiatives is also crucial. OECD countries made extensive use of professional and industry associations to support awareness programs. In Denmark and Sweden, technological service institutes play a major role in training, consultancy and advisory services, as well as in carrying out contract or cooperative applied research linked to diffusion programs.

Finally, a major lesson is the need for systematic monitoring and review of these programs. Continued assessment is crucial to where to target funds, what types of activities needed, when to shift emphasis from some activities to others or whether to modify or terminate
such programs. Periodic surveys and feedback from user associations are critical to continued evolution and learning in applying a fast changing technology.
### Table 3: Major supported by national microelectronics diffusion programs

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<th>Program Activity</th>
<th>Denmark</th>
<th>France</th>
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<td>- Applications/demonstration projects</td>
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<td>2. Consultancy assistance</td>
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<td>3. Market identification, exploration and development</td>
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<td>4. Process development/process applications support</td>
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<td>5. Product development support</td>
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<td>6. Enabling infrastructure/information channels for technology transfer:</td>
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<td>9. Broad education programs (secondary, tertiary, adult education)</td>
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1 Special program only.
JAPANESE AND SINGAPOREAN EXPERIENCES: COMPREHENSIVE STRATEGIES

Japanese Experience

The Japanese experience in diffusing electronics and IT stretches back to the 1950s. Unlike many other OECD countries, there have been few shifts in emphasis on diffusion in Japan's IT programs. MITI's vision of the 1970s envisaged a knowledge-intensive industrial structure. It viewed IT industries as having high income elasticity of demand, rapid rate of increase in productivity, and energy-conserving and environmentally-friendly impact. Japan's industrial policies focussed increasingly on allocating resources preferentially to knowledge-intensive industries, mainly IT. Subsequent visions for the 1980s & 90s maintained the main thrust of promoting "knowledge-intensive" industrial structure. They aimed at promoting "future-oriented technologies" and "knowledge-intensity" in all types of industry.

Japan's IT programs tackled a broad spectrum, along the supply, demand and infrastructure. Schemes included: major cooperative research projects, R&D tax incentives, R&D loans for small firms, subsidized financing to software houses, government procurement policy, privatization and modernization of telecommunications, training or electronic and software engineers, a wide range of finance schemes and incentives for IT applications, and a number of special programs to promote the diffusion of particular technologies and applications, e.g. industrial robots, packaged software, artificial intelligence.

Perhaps most interesting is the recent MITI program to promote joint ventures and subsidiaries in Asian countries for software development and training. The fast growing demand for software in Japan and the scarcity of supply has driven Japan to offer Asian students a three year program in Japanese language and systems engineering education, with the hope to enlarge the pool of systems developers for the Japanese market. This can be a major market for the Indian software industry.

Singapore Experience

The National Computer Board (NBC), working closely with the Economic Development Board, Singapore Telecom, and representatives of the private sector, have formulated a comprehensive national IT strategy for the 80s. The twin objectives of the IT plan were: to develop an export-oriented IT industry and to exploit IT to improve productivity and competitiveness in all sectors. A well coordinated infrastructure was developed: communication infrastructure, IT manpower, a conducive environment for the usage and development of IT products and services, and collaboration among public agencies and private associations.

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The strategy included seven building blocks: IT manpower development, IT culture (computer and information literary), multi-media telecommunication and electronic networks, IT diffusion in government and business (strategic applications, public databases, assistance to small businesses), support to R&D institutions and incubator centers, promoting niche IT industries (especially software and computer and information services), and collaboration among public, private, academic and foreign actors.

The Singaporean experience offers many interesting lessons. The civil service computerization program aimed at mobilizing domestic demand and providing demonstration effect for the private sector, as well as enhancing the productivity of the public sector and the provision of information infrastructure (public databases) for the private sector. The NCB placed their staff within various ministries to provide technical assistance in determining information requirements, IT procurement, and the initial implementation period. The NBC also coordinated investment in common data networks and databases, designed around common data formats and communication protocols. While acting as a central facilitating and outsourcing agency for the government, NCB did not substitute for top management leadership which chaired the IT committee within each industry.

The IT diffusion program aimed at promoting best practice in computer use through the economy. An interesting example is the small enterprise computerization assistance scheme, whereby NCB, in collaboration with other agencies, finances (up to 70% of) consultancy services to small and medium enterprises to computerize in the correct way and in line with their business strategies.

Information dissemination and the development of an IT culture covered many activities. NCB organized annual national conferences on IT applications, conducted annual surveys of IT uses in key sectors, and provided IT awards for outstanding applications. Mass media assistance was enlisted. NGOs, trade associations, user associations, and educational institutions were also enlisted to educate their members in IT concepts through their educational programs.

Promotion of IT industries included software development assistance schemes that provides cost sharing (of up to 50%) or conditional loans to cover product development costs for items such as feasibility studies, external consultancy and technical documentation. Such schemes were targeted for small software houses. Other schemes included software quality improvement and recruitment and incentives for multinationals to provide advanced IT training, research, and export services. However, the IT industry has been viewed mainly as a key input to enhancing Singapore's competitive advantage in all other industries and services, and not only as an export earner.

Singapore is currently building on the successes of its first IT plan, and has just
completed the design of its IT 2000. The new strategy builds on the infrastructure, policy, standards and manpower already developed and identifies strategic programs to link various islands of information throughout the economy and to make Singapore a business, information, communication and transport hub for East Asia. The IT 2000 strategy envisages a national information infrastructure that carries and provides a wide range of services, information and communication. To build the varieties of common services for this infrastructure, the strategy calls for joint public-private programs to identify and finance major applications in education, manufacturing, commerce, tourism, construction and other key sectors of the Singaporean economy. Singapore views this effort as one of building the core infrastructure for national competitiveness for the 21st century.

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SOFTWARE EXPORT DEVELOPMENT FUND (SEDF)

Introduction

The Indian software export industry has shown an impressive compound annual growth rate (CAGR) of 40% from 1985/6 to the 1990/1 figure of US$128 million. However, the export growth has come mainly from the provision of contract programmers to carry out low level work ("bodyshopping"). There are a number of undesirable aspects to this (para. 3.13), including:

- Bodyshopping is often an on-site service; once the personnel are abroad, the temptations to remain abroad are frequently not resisted.

- The domestic sector also suffers in that even those who do return have gained little or no experience of larger scale project management.

- The perception of Indian software skills in the target markets remains unjustifiably low.

- Demand in the target markets for skills at the low level end of the spectrum is likely to be increasingly eroded by the growth in development tools that automate many of these tasks.

- Last, this type of work is less rewarded than higher value-added and higher skilled work.

These problems point to the need for an export effort tailored around winning higher value-added work. Thus far only a handful of Indian software companies (TCS, TUL, CMC) have pursued this approach with any consistency. There is little evidence that the experience gained by the personnel of these companies is permeating through to the rest of the industry. Furthermore, because of their considerable and untypical resources, these large companies do not in general provide a relevant model to Indian software exporters as a whole; for instance an overseas marketing and support office is beyond the scope of the majority of would be exporters.

One of the key constraints to the growth of software exports from India identified in a recent Bank-funded study is in the area of marketing. The study cites the need to strengthen both the capabilities of firms to design and implement marketing programs and to have greater access to international expertise and information in the area of marketing software and related services. The techniques that are used are often not suited to the more mature

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markets where exports are being targeted. Budgets, too, tend to be low; few package producers for instance are devoting anything like the figures of 70-80\% of revenue which worldwide package producers typically allocate to packaging and marketing. There is also little evidence of strategic marketing; many software companies in India rely on "word of mouth" as their main or only source of export work. Furthermore, because of the traditional difficulties of obtaining foreign exchange, funding of export marketing efforts has been difficult for Indian software companies; the corollary of this is that direct knowledge of the target markets is also limited, thus undermining those marketing efforts that are made.

While it is perhaps early to make judgments on recent programs by multilateral and bilateral agencies for Indian software companies to extend their markets, much of this assistance has either been unduly concentrated at the generic level, or isolated initiatives, such as subsidizing appearances at Trade Fairs. The results of generic market research is often too generalized for any individual company to make meaningful business decisions. While there is an obvious need for this type of generalized market research and direct assistance, it should be mixed with a more focused approach, working with selected companies on a one-to-one basis. Such an approach has several advantages:

(a) individual market opportunities can be accurately fulfilled;
(b) focused, niche marketing can be encouraged;
(c) success monitoring is much more accurate;
(d) individual companies can be assigned individual targets;
(e) the contribution and commitment from individual companies selected is greatly increased; and
(f) in-depth experience gained at the individual level can be fed back for the benefit of the software community as a whole.

_Eligible Activities._ Activities to be funded through the Software Marketing Fund (SEDF) would include: (i) market assessments of export readiness (company, products, and/or services); (ii) preparation of individual, detailed marketing strategies and plans; (iii) fees and travel expenses for implementing marketing strategies and plans; and (iv) purchase of information abroad, in support of marketing activities, where there is a requirement for assessment of overseas market niche potential.
Term-Lending. A total of US$17 million would be made to the Electronics and Computer Software Export Promotion Council (ESC) in the Ministry of Commerce for onlending to both governmental (e.g., NIC and CMC) and non-governmental software enterprises for export-oriented subprojects. Although ESC will have the flexibility in choosing subprojects to support with the loan funds, it is expected that a focus would be on export marketing needs of smaller and medium-sized companies, including companies located in the DOE's Software Technology Parks.

The eligibility criteria for export orientation of subprojects would be through a standard assessment methodology that has been successfully used in company selection and induction programs of other software marketing programs. The criteria to be used include, among others: export readiness, domestic track record and stability, evidence of prior commitment to exports, definite focus on products and services suited to target market(s), technical and managerial competence, level of marketing awareness, etc. Experience has shown that selection is a key element of success to ensure participants are fully committed to the export effort. Along with the individual marketing strategies will be targets set for each participating company. Companies will be expected to generate an average 20:1 return (ratio of exports achieved in 5 years to costs of consultancy provided). These targets will be routinely monitored. Such an overall approach would take a firm from its present exporting situation to a future situation representing a significant expansion in export performance.

Participating Institutions

A number of international and bilateral organizations have been involved in marketing program support to the Indian software industry, often times resulting in haphazard and uncoordinated assistance. Interested agencies, and possible co-financing agencies, would be contacted to discuss their interest in participating in this programs. The UK Overseas Development Administration DeCTA (the Developing Countries Trade Agency) has already expressed an interest in co-financing the fund. Any participating agency would be selected largely on the basis of their interest and success in supporting the growth of software industry efforts. As part of project preparation, the Bank will work closely with them and reach agreement on project implementation issues such as staffing and management of the fund.

The Developing Countries Trade Agency (DeCTA)

DeCTA has been working in India for 10 years now, and always insists on a result-oriented approach, concentrating on helping a few carefully selected companies by subsidizing the consultancy costs of specialist European sub-contractors. The software program of DeCTA is trying to change the current perception of India as a provider of low cost computer software coders to one where the country is recognized as a source of all the necessary skills for the management and coding of high quality software. Companies selected in the program are expected to generate a 20 to 1 ratio of exports achieved to program costs.
software program was funded by the ODA for 3 years at a cost of L500,000. The program finishes in March 1993.
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