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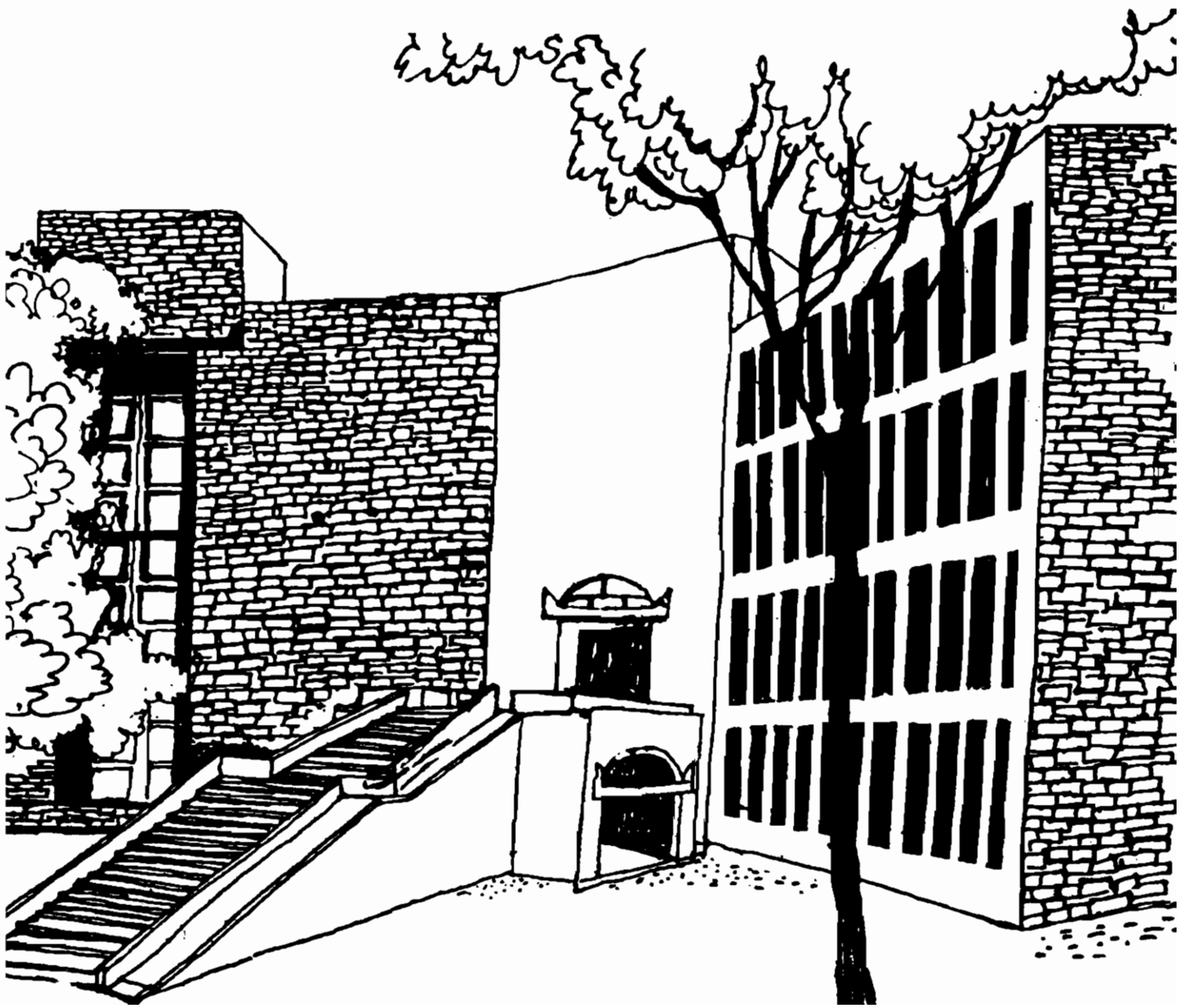

EXPLOITING THE POTENTIAL OF THE INDIAN SOFTWARE INDUSTRY

By

Shekhar Chaudhuri
C.B. Dasgupta

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INDIAN INSTITUTE OF MANAGEMENT
AHMEDABAD - 380 015
INDIA

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Exploiting the Potential of the Indian Software Industry

1. Software Industry in India: Genesis and Growth*

The Indian Software industry compared to the other sectors covered in this research is relatively young. A few years ago, hardly a score of firms employed more than 50 software developers. Today the number of such units has increased manifold. The software industry's upsurge started in the beginning of the nineties. Though exports are the cynosure of software firms, quality of the software is also gaining importance. While some units have already acquired the prestigious ISO-9000 certifications, several others are queuing up for it. It is evident that the industry is rapidly emerging out of its cottage industry status. Overseas recognition and acceptability have made things easier. The Indian software industry accounts for only 2% of the world's software industry output. Between 1986-87 and 1991-92 the total output of Indian software industry increased from Rs.1600 million to Rs.7320 million. Software output accounts for 27.9% of the total information technology industry output of Rs.26231 million during 1991-92. During 1991-92 software exports increased to Rs.4142 million compared to Rs 2500 million in 1990-91.

Computer usage in India dates back to the late 1950s. From that point in time, up until the end of the 70s, even though hardware in use passed through successive generations, computer usage patterns remained relatively static. There were broadly two categories of users - commercial and scientific; the latter including academic and defence users. In the commercial sector IBM, ICL, and other mainframe vendors sold computers and provided data centre services. However, in terms of hardware, India was always one or two generations behind with manufacturers citing immature user bases as the reason for not introducing advanced hardware. In this sector, the major Software vendors were the hardware manufacturers and some software houses (of whom the largest was Tata Consultancy Services, or TCS - they are still the largest).

Users with in-house computers tended to be large organisations, who often had their own EDP departments, and hence could do the necessary development. Those who used data centre services also tended to let the service provider handle software development.

Scientific users tended to have their own software capabilities. They also had more contacts overseas, and compared to commercial users were less subject to import restrictions.

As a result, the scientific sector, right from the beginning, had the more advanced computer users. Apart from mainframe vendors, DEC was a favourite in this sector, reflecting worldwide trends. The only domestic hardware manufacturer was ECIL, with computers similar to DEC's.

This situation changed dramatically between 1977 and 1980, due to two events. During this period the coalition government led by the ultra nationalist Janata Party enforced a number of restrictions on multinational corporations through increased stringency of the Foreign Exchange Regulations Act (FERA). Multinational corporations (MNCs) were asked to dilute their equity holdings in order to continue doing business in India. As a result some MNCs left the country. In 1977 IBM withdrew from India, leaving a significant vacuum.

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* Note: Acronyms and abbreviated names have been expanded in Appendix A.

During 1978-79 the industry experienced a major technological change. The microprocessor revolution arrived, with many manufacturers introducing locally designed microprocessor based machines designed at the time for data processing rather than as PCs. This led to the sudden availability of low cost computers, increasing computer penetration and an unprecedented demand for software. The majority of today's software companies (including the majority of those in this survey) were formed at or after this period.

Around this time, also, the government began attempts to promote software exports, and major exporters like Tata Unisys Limited (TUL) got started. Special export zones were created where hardware could be imported duty free and imports were also allowed elsewhere against export obligations.

Worldwide, the introduction of the IBM PC in 1981 altered the computer scenario by standardising the Personal computer and thus enabling it to move into homes and offices.

However, in India, three digit import duties pushed the costs of PC class machines to levels appropriate only for data processing, and not for personal or ordinary office use.

This last barrier was removed in the mid 80s, with dramatic reductions in hardware import duties and restrictions.

This import smoothening, attributed to the personal initiative of the then Prime Minister, Rajiv Gandhi, and accompanying changes, arguably mark the beginning of the currently ongoing liberalisation process, even though some efforts in this direction had already begun in the early 80s.

Subsequently, there have been no comparably revolutionary changes, but there have been major evolutionary ones. One is the increasing exposure to worldwide trends due to the progressive liberalisation. In fact, today, the very need for export zones is fast disappearing, and, with global big names entering the country, domestic industry finds itself facing global competition from imported products.

Many of those surveyed have responded to this challenge by trying to professionalise their management - by adopting techniques like Structured Systems Analysis and Design (SSAD) and the ISO 9000. It is significant that much of this has happened only over the last few years.

An equally important change is the acceptance by Indian society, of a computer culture over the last decade. While, in the mid 80s, computers were not understood, and were widely opposed as labour displacing devices, today, even small shops in big cities are computerised, and computerised procedures in areas like railway reservations or banking have led to a widespread understanding of what the whole thing is about.

On the international front, the next revolution building up is the increasing use of Client Server computing - in which networks of PCs take over much of the functionality earlier provided by minis or mainframes. Over the last two or three years, more and more Fortune 500 companies have begun to "go client server".

Ironically, India, due to its very low mini/mainframe installed base is very well placed to move into client/server relationships.

In software development, there has been a consolidation in many areas, with clearly dominant standards emerging in each. Examples are the 'C' language in programming languages, the use of

Relational Data Base Management Systems (RDMS) in data processing, the use of "Windows" style interfaces in user interaction, etc.

This consolidation can be expected to increase the software production base by reducing the fragmentation of skills which had previously acted to confine programmer availability to only those familiar with the languages/tools in use by the user concerned.

Tables 1.1, 1.2, 1.3 and 1.4 provide data on various dimensions of software production and exports.

Table 1.1

Software : Domestic and Export Sales

Sector	1985-86		1990-91	
	Rs.crores	US$million	Rs.crores	US$ million
Domestic	70	57	225	115
Exports	30	24	250	128
Total	100	81	475	243

Source: Electronics Information and Planning, January 1993

Table 1.2

Software Revenues from Different Activities

Software activity	Domestic	% of total	SW (Rs)	Exp % of Total
Turnkey	1155	51	-	-
Professional serv	-	-	1500	60
Customized	415	19	430	17
Stock & Sale*	360*	16	-	-
Packaged	200	9	120	5
Consultancy	76	3	370	15
Others	44	2	70	3
Total	2250	100	2500	100

Source: Electronics Information and Planning, January, 1993.
* Imported Software

2. Evolution of Technology Institutions

As a result of the dramatic changes that have taken place since the mid-80s the Indian software industry has experienced very rapid growth and seems to hold a lot of potential for the future.

Table 1.3

Computer Software Exports (US$)

Year	$ Million	% Growth
1987	52	-
1988	66	28.3
1989	95	44.1
1990	114	19.9
1991	148	29.6
1992	184	23.7

Source: Electronics Information and Planning, May 1993.

In the commercial sector, the bulk of pre-PC computer usage involved fairly standardised applications, in big firms having their own EDP staff. Indeed, the very fact of computer usage indicated a certain size of organisation. In such firms, the in- house staff developed the necessary application know-how and the manufacturer provided (computer) model specific know-how.

Of those who now qualify as technology supporting institutions (TSIs), only the educational institutions existed at the time, and they had little interaction with industry. In the academic and scientific sector, users tended to be a lot more knowledgeable, and, in most cases, developed the necessary skills in-house. Organisations in this sector also had extensive contacts with their counterparts in other countries, which they used to make up for any deficiency in skills or know-how.

The eighties were characterised by an increasing awareness in the government that the research establishment was not contributing much to industrial development. This decade saw certain moves to remedy this, starting with a stipulation in the mid eighties that all research institutions undertake some industry related projects.

Table 1.4

Countrywise Export of Computer Software from India (Rs.Million)

Country	1990	1992	Compound Growth Rate
USA	1200	2610	47%
USSR	20	20	-
Europe	580	1620	65%
Asia and Oceania	200	750	95%

Source: Electronics Information and Planning, May 1993.

Around this time, the first of what may be termed the "second generation" research labs were founded. These had the upgradation of industry as one of their prime objectives, and the atmosphere in them tended to have more of a corporate orientation, as compared to a "pure" educational institution. The process was given fillip when a series of Technology Missions were set up, as well as C-DOT, a research organisation meant to develop advanced telephone exchanges, and whose organisational structure was intended to serve as a prototype for a new kind of research institution.

Of the two "second generation" TIs in this survey, one, the National Centre for Software Technology (NCST), dates back to the early 80s phase, while the other, Centre for the Development of Advanced Computing (C-DAC), modelled on C-DOT, was set up in the later part of the eighties.

3. Industry Structure, Technology Institutions, Government Policies and Firm Perceptions

3.1. Types of Firms*

There are around 500 companies in India manufacturing software for domestic as well as export markets. Apart from these there are many firms which develop software for in-house use related to business automation, process automation, decision support, etc.

The industry has seen explosive diversification over the last ten years, and the following categories of firms can be identified. It emerged from the survey that this same categorisation can, to an extent, predict TI usage also.

a) Diversified Export Houses: These are firms with a significant overseas presence, marketing their own services and products abroad. These tend to make extensive, if somewhat scattered, use of TIs. This survey covers the only firms in this category - Firm 04 and Firm 05.

b) Captive Export Houses: These undertake a significant amount of software development for a single foreign partner. The latter may use these products and services or may sell them in turn.

In the survey Firms 08, 10 and 13 fall in this category as do the - much smaller - Firms 09 and 17. These firms acquire their technology needs almost exclusively from their foreign partners - they hence tend to characterise the offerings of Indian TIs as not quite relevant to their needs. However, the possibility exists that technology obtained from joint venture partners could in turn have been obtained by the latter from TIs in their own countries - more so in "high tech" ventures.

c) Bodyshoppers: These are export houses with an emphasis on providing contract labour, rather than pushing their own products or skills. While some bodyshoppers remain exclusively in that category, others attempt to come out of it by using their contacts and resources to push more of their "own" technology.

While there were no firms in the survey which are exclusively into bodyshopping, Firm 07 and the export divisions of Firms 06, 12 and 15 have a mix of body shopping and development contracts. Firm 15 is also in the process of pushing one of its own products. Firm 11 has 15% of its revenues from exports, but the nature is not known. Bodyshoppers do not generally require too many technology inputs and hence need no help from TIs.

d) Firms engaged in overseas contracts for products and services:

These tend to pick up their technology needs mostly from overseas sources, but also - particularly when large amounts of training are required - from local TIs. An interesting case is that of Firm 06 which is staffed by ex Firm 05 personnel, and uses 05 - the industry's leader - as a role model. They

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*** In surveying the industry, it should be understood that, unlike many industries, software is characterised by a significant amount of what Alvin Toffler terms in "The Third Wave" "prosuming" i.e. producing and consuming by the same entity. This happens since many users develop their own software in-house. Prosuming has become even more widespread with the proliferation of low cost PCs. Of necessity, this survey has been confined to those who produce software for others, but it should be understood that, because of prosuming, a lot of software development and usage will fall outside the survey's scope.**

have picked up procedures and management style from 05, leading to the conclusion that 05 serves as their TI!. The firms mentioned above also operate in this category.

e) Agency Businesses: These are firms that sell imported software products. As most imported software products tend to be complex and general purpose they require a considerable amount of effort in their installation, customisation, and subsequent support. In many cases, the importing agency does a substantial amount of development on these products in their own right.

Companies in this category in the survey include Firms 04, 05, 08, 10, 12 and 15. In an agency operation, the importer gets trained by the foreign firm exporting, and becomes the source of product knowledge within the country. TIs do not generally get involved.

f) Niche Players: These are firms who have developed considerable expertise in what the industry calls a "vertical market" - a specific application area such as banking or sharebroking. They then use this expertise to develop custom software for clients which, more often than not, is a single product where modifications are made according to client's needs. Sometimes the product is sold as such.

In this survey, Firm 11 in the hospitality market and Firm 12 in the share broker's market are examples. Here, application knowhow comes from users, not from TIs. Development knowhow is generally available in-house - the products are usually commercial packages which do not require very demanding programming.

g) Product Innovators: These are firms who have developed a new product or a major variation on an existing product.

Examples in this survey include Firm 14 with their Executive Desk package, Firm 16 with their Tally package, and Firm 05 with the EX Financial Accounting package. These firms do have a need for outside help in this kind of development. Both Firm 14 and Firm 16 said they would have appreciated help, but felt that existing TIs were not the answer. Firm 05 said they used a large amount of external feedback, including some from consultants, but did not specify whether these consultants were from any TI.

h) Package Experts: These are firms who become familiar with a particular software and sell their expertise. The role they play is that of an agency house, except that the package is not imported by them.

None in this category emerged in this survey.

i) General application developers. These are software houses who undertake any kind of software development, and, to some extent, the majority of firms in the survey fit this category since none of them indicated that they would refuse to enter any area.

However, the need to concentrate resources tends to force most firms into one or more niches - based, not only on application expertise, but also on programming language, computer type, etc.

The one common theme from all such respondents was the need to adopt structured development methodologies (SSAD being the most common) and to get ISO 9000. In both these areas, firms sought outside help, and even firms which made no other use of outside organisations, went for assistance in SSAD and ISO. It should be kept in mind that in software, manpower is the biggest cost, and

management of the development process is the equivalent of production plant control in other industries.

3.2 Technology Institutions

Activity in the area of computer science in India started in 1954 when the Tata Institute of Fundamental Research (TIFR) initiated development of a computer code-named TIFRAC (TIFR automatic calculator) considered as the state-of-the-art system at that time. This was completed in 1959. Subsequently other institutions like Indian Statistical Institute (ISI) and Jadavpur University also undertook R&D work in developing the ISIJU computer. The Bhabha Atomic Research Center (BARC) commenced development of the TDC-12, a commercial computer based on the popular PDP series of the Digital Equipment Corporation (DEC). Academic institutions also acquired computers.

Till the advent of "second generation" research labs (See Box 1 and 2) mentioned earlier, universities and colleges with Electronics Engineering and/or Computer Science departments were the only organisations which readily came to mind as software TIs.

During the 1970s a chain of Regional Computer Centres set up in various parts of the country, as well as other Government labs dedicated to electronics. Before NCST, there was no lab dedicated solely to software.

We are not aware of any private sector software labs which have been perceived as TIs.

Of all these possibilities, the Indian Institutes of Technology and the Indian Institute of Science at Bangalore were thought to be the most likely TIs, and this was confirmed during the survey, when respondents who sought to work with an academic institution were most likely to approach an IIT or the IISc.

At the same time, it should be kept in mind that many other engineering colleges are engaged in varying degrees with industry, some having built up enviable reputations, usually in their immediate geographical areas.

Apart from universities, the "second generation" labs mentioned earlier play a significant role, and - especially NCST, which is the only TI dedicated to this industry - seem to be favoured in the industry's perceptions.

How do TIs interact with industry?

The IITs have an increasing volume of consultancy projects from industry. While a certain degree of such work has always been carried out, over the last few years the process has become a lot more formalised, with special cells being formed to handle industry interactions.

Software projects, as well as other industrial consultancy projects, may be divided into two categories

- those where the Institute receives the income (IIT Bombay terms these "sponsored" projects) and those where individual professors receive the income, with a share going to the Institute (these are termed "consultancies").

In both categories, projects are assigned to individual professors (who would usually be in the Computer Science or Computer Engineering Department), who then become responsible for carrying out the work. Selection of the professor could be done directly by the client, or, should the client

Box 1

Centre for Development of Advanced Computing (C-DAC)

The institution was established in 1988 to design, develop and deliver super computers by the Department of Electronics (DoE). The reason for setting of this institute was that the technology for supercomputers was not readily available to the country thus hampering development in various fields (e.g. meteorological forecasting). It is a generic type of technological institution. It was set up as a scientific society in line with C-DoT under DoE, thereby giving it greater autonomy in its decision making than the existing CSIR laboratories. But all the R&D activities of this TI are funded by DoE as its output is of national importance and because of its large requirement of funds (Rs.30o 120crores per year) which is unlikely to be funded by private parties. Part of the income comes from contract R&D and manufacturing. Government influence exists through funding support and determining the broad research and technology agenda.

The mission of the institution has been to develop super computers indigenously for which it is involved in the development of parallel processing hardware, software and techniques. For realizing its mission the institution has been provided with the latest facilities and equipments like Very Large Scale Integrated Circuit (VLSI) manufacturing process and electronic hardware fabrication equipment.

The institution has its technical orientation towards strategic R&D with focus on industry needs of the future than on basic and academic R&D. This is visible in the greater importance attached to practical achievements in evaluating the performance of its technical staff and no importance attached to academic achievements (publications). In working towards its mission the institution keeps itself abreast of the latest technological developments in the world which could be put to use by it. Its practical achievement orientedness is evident in its technology acquisition/development strategy whereby it first tries and uses existing solutions, failing which it tries get technology from outside and finally tries to develop technology in-house. This is due to the fact that the institution's mission is to get technology fast into the user's hand. This strategy has paid off in the institution being able to develop a state of art parallel computer PARAM in its existence of 5 years. It has also bee able to transfer GIST products, for multilingual technology for commercialization.

Out of its total 160 staff, about 110 are technical staff whose average age is low. This is its greatest asset as young people are more motivated to come up with innovations. The success of the institution lies in its management and culture. A problem solving approach adopted by researchers as well as the practice of identifying specific study tasks ensures that projects are directed. The informal work culture cuts down the bureaucratic wrangles and thereby ensures timeliness. Pride in their achievements and the knowledge that they are the technological "torch bearers" motivates the staff in their efforts. Also motivation is derived from the emphasis given to practical achievements in evaluation.

For developing its internal capabilities the institution places emphasis on "homegrown" technology based on worldwide technological trends. Technology induction has been mostly through study of published material. For training its own staff the institution has its own training school - Advanced Computer Training School (ACTS). It also has a lot of interaction with other outside institutions, both public and private which act as co-developers. It uses private firms for manufacturing and marketing facilities which is lacking in-house.

It also has a lot of interaction with its clients whose feedback it takes in developing its next generation of products. To be more market oriented the institution is planning to do more market research to determine its products.

approach the Institute directly (instead of any individual professor) then the Institute authorities will then recommend a suitable individual.

Box 2

National Centre for Software Technology (NCST)

This institution was established in 1985 as a national software laboratory by the Electronics Commission of the Government of India. It had its genesis as a group set up within TIFR. The TIFR environment in which it was born provided it with the culture of greater accountability, international orientation and autonomy that is the case with other labs. Its ownership is partly governmental with government grant constituting 30% of the income, while the rest comes from the sale of services. The primary missions of the institution are to carry out research and development in software technology, undertake educational and training activities and support industry through R&D. The organisation has a strong applications orientation towards industry while basic research does not get that much importance. This is evident in the evaluation of technical staff where more importance is given to practical achievements than academic achievements. It defines its role as a leading edge assimilator of technology for its industrial clients whom it serves through development and joint projects, training courses and products developed in-house.

To keep up its technological level it has acquired the latest facilities in technology in terms of computing hardware, communication and library facilities. But to operate the hardware it requires competent personnel. To update the technical capabilities of its personnel the institution organizes training under UNDP fellowship for specific projects, sends people to international computer manufacturers for training and arranges courses, workshops and conferences in India by invited experts. To keep itself abreast of the latest technological development the institution collaborates with various universities in India and abroad for joint research, conferences and workshops and with R&D oriented companies like CMC and Tata Consultancy Services it collaborates for joint technical activities. Also to develop internal capabilities the institution has created a new centre at Bangalore, set-up a new division in software engineering, entered into MOUs with universities, both Indian and foreign, and companies from abroad for technical and scientific cooperation.

For the future the institution does not see a change in its objectives but believes that a higher level of technical support needs to be provided to clients which necessitates that it should invest more in R&D and maintain high level of effectiveness of R&D so that it can benefit from the technological developments. But at present the institution is quite successful and has been referred to by most of the software firms for technological needs albeit the low level of publicity that the institution possesses.

Projects include both, consultancy, as well as contract design projects. The latter could be carried out entirely in the campus and handed over to the client - the former would, naturally, involve spending some time on the customer's premises.

The other form of "interpersonal" interaction is the conducting of courses. The IITs concentrate on their own students and run relatively fewer courses for industry participants, though there are indications that they may plan to increase the volume.

In terms of "passive" interaction - provision of facilities - IITs have always hired out computer time. The users are also provided a certain amount of expert help at the computer centres, which is not billed separately; and library facilities.

"Second generation" laboratories or technology institutions who see industry interaction as a part of their primary mission (the complete mission is seen as maintaining excellence in a given technical area and passing on technology to industry) naturally have a higher degree of such interaction. NCST, for instance, runs an extensive series of courses for participants from industry, undertake development projects, and offer, not just library facilities, but also other services such as Electronic Mail.

As regards the vital factor of employee attitude to industry consultancy, second generation laboratories tend to ensure that a significant percentage of their personnel would have, at least, a favourable attitude.

In IITs and other engineering colleges variations may be expected in this regard. IIT Bombay, which was surveyed, has taken a pragmatic approach. It recognises that not all faculty members have an aptitude for industry interaction, and they do not necessarily see this as a bad thing, given that research and teaching continue to be their primary aims. IIT Bombay is, rather, striving for balance, by trying to ensure that each category (consultancy, teaching, research) is adequately staffed by competent and motivated individuals.

At the same time, they pointed out that this approach was not representative, and that there were colleges around (no names were given) which were still a lot more tradition in their outlook.

The National Informatics Centre (NIC) was established as an autonomous agency under the Planning Commission (Hanna, 1994). Its role is to develop management information systems and introduce information technology in government departments. It has a qualified and motivated staff including over 2000 engineers, 50 per cent of whom have masters degrees or higher qualifications. Some of its major achievements are; (a) development of a large satellite based communication network - NICNET - with more than 500 user terminals connected to modem, inexpensive receiving terminals in district, state, and central government offices; (b) installation of more than 350 medium and large databases that are available through NICNET; (c) development of some 100 software packages for high volume transactions, district planning, and computer-aided design/computer-aided manufacturing (CAD/CAM); and (d) training of more than 10,000 central government civil servants in the use of IT and data communications.

3.3 Government Policies and Firm Perceptions

To understand the government's role in the development of the software industry it would be necessary to see it in its organic relationship to the evolution of the electronics industry. In the early sixties the government felt the need to build a technological base in electronics for strategic reasons. However, according to C.R. Subramanian (1992) the period 1970-78 did not produce any worth while results. In 1982 a review was done of the existing computer policy and finally in 1984 a new computer policy was announced.

This policy removed capacity restraints,stressed the protection of the local industry through import curbs, and a general liberal approach for the growth of computerization. The policy was followed by changes in custom tariffs and import policies to help the industry grow through assembly of CKD/SKD packs. Since these changes were made on an adhoc basis, it was difficult for the industry to plan long term.Such a policy did not lead to the development of computer industry in India but only made availability of computers more easy. This policy virtually killed domestic R&D as imports of both hardware and software was easy.

The new policy also covered some aspects of software development and export.It promised to develop R and D facility and a software development agency without a very clear definition of their roles.

In 1986 a new policy was announced.There was nothing significant about this policy except for a high export obligation for import of computers for software exports.

All these measures have not made any impact on the development of the software industry according to senior executives of software companies surveyed.

During the period 1985-89 there existed many variations in the import/excise structure. For eg. computers specifically used for the export of software could be imported at a 65% duty,at 35% duty under the EXIM bank scheme,and if imported for a short period on a returnable basis ,at a duty of only 20%.

Till the eighties the government did not appear to have any major software related policy direction. The major emphasis was on reducing imports (not just in software, but in all sectors of the economy) and in software this took the form of encouraging local development of any software needed. This path was always taken as preferable to importing packages, though its downside could show up as poor quality and long development cycles. As far as software exports were concerned, for India the obvious advantages were the low entry costs and emphasis on individual skills, both of which suited the country.

But there were also significant disadvantages. For a long time, hardware sold had been a generation or two removed from what was available overseas, resulting in a lack of exposure to the latest technology. The only area where India was on par with foreign countries was at the "low end" - personal computers. But, for whatever reasons, PC software was never made a thrust area for exports - reasons could include low margins, the disorganised and diverse nature of the market, and the fact that - in those days - the influential EDP/MIS community was not very PC oriented.

Another problem, which became slowly apparent, was that years of "go it alone" software development had left Indian programmers with no exposure to modern project management techniques. In fact it was the other way round - there were bad habits to "unlearn". In fact, it took time to realise that development time had to be seen as an integral part of software quality, and that the best quality of (program) code could not compensate for delayed deliveries. India suffered from several problems in this area, in particular.

One, the lack of modern hardware meant long learning curves for programmers who had to master new systems before starting export projects. Secondly, a legacy of the import control regime was the inordinately long time it took to import a computer[1].

Third, and possibly the most damaging, was the lack of project management experience.

Software "production", in many ways a creative process that requires constant monitoring if schedules are to be met, is affected by a high job mobility among programmers, leading to frequent mid-project departures. In India, most users till recently had low computer awareness and accepted whatever development time the EDP department managed to achieve.

Also, perhaps due to the "self reliance" ethos then prevalent, considerable "re-invention of the wheel" was done, and Indian programmers were not accustomed to using off the shelf software and hence often lacked the discipline needed to make their own output usable by others. However, lack of software re-usability is a worldwide problem, more so given the highly individualistic nature of the more creative programmers.

One of the important feature of government policies today in the software area is creation of independent "islands" for export purposes where the infrastructural problems, at least, would be alleviated.

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1 Due to a lack of an installed base of modern hardware, exporters could either send programmers abroad - which was expensive and made them difficult to control - or had to import hardware, often involving delays of weeks or months.

In these "export islands" (which are either physical ones, in the form of export zones/software technology parks; or consist of procedures and regulations governing export activities of an industrial unit), hardware and software can be freely imported, and there are no duties, and a minimum of paperwork. The only restriction is that the equipment be used solely for export. There are also some fiscal incentives.

Department of Electronics has set up Software Technology Parks at various locations in the country in order to provide facilities like built-up accommodation, communication link and core computing facilities. In 1990 three software parks were established in Pune, Bangalore and Bhubaneshwar. In 1991, the government set up four additional parks.

During 1992-93 these parks achieved the major goal of providing and managing the infrastructural facilities like common computing platforms and data communication facilities. They have also attracted many NRIs, MNCs, private entrepreneurs, etc. Till December 1992, the software technology parks accounted for Rs.260 million worth of exports.

In all other matters pertaining to software (except for the setting up of NCST to function as a national software lab) there have been no policy initiatives of comparable significance, though there have been rules passed and committees set up. In the survey, when responding to the question regarding the impact of government policies, respondents talked largely of export promotion measures.

Major candidate areas mentioned by respondents with no government policy initiatives (or only weak ones) include anti piracy issues, virus protection, directions for domestic software development, definitions for taxation purposes, software quality certification standards, software specification standards for government procurement, and certification measures for software professionals.

One other area must also be mentioned here, where there has been policy initiatives. In computer education, the Department of Electronics - has created syllabi and examinations at various levels.

Also, in the main thrust area of software exports, all the measures, though highly appreciated by industry (respondents invariably rated export incentives as 5 on a 1 to 5 scale) may not have led to the desired results. India still has only a small part of the global software market.

A very major change, though, is the extensive computerisation of the government's own functioning which has taken place over the last few years. Government's moves in the future will undoubtedly be influenced by the widespread awareness that this will create, though, with increasing liberalisation, the government's regulatory role in industry can be expected to decrease though the developmental role would have to increase.

The issue of manpower supply is very important. The 'brain drain' takes away the best computer related manpower of the country and among the best in the world. Government has set up several engineering colleges which offer Master of Computer Applications (MCA) courses for training computer specialists. However, the requirement of B.Tech. and MCA professionals is 18000 over the next five years against a projected supply of only 5000. The acute gap between supply and demand leads to increased manpower costs, job hopping and consequent wastage due to dislocations. This scenario is unlikely to induce employers to provide training inputs to their employees which is extremely necessary in the context of fast changing technology.

One of the problems in meeting the manpower demand is the lack of faculty members with required qualifications and experience. Also, there is the high cost involved in installing new computer systems

in engineering colleges. As a result, not many students are accommodated in Computer Science branches of various engineering colleges vis-a-vis those in other branches.

Several private companies like NIIT, Apple, Brilliant etc. have found training people to become systems analysts or programmers as an attractive area owing to the demand supply gap and lack of adequate facilities for grooming them. Many organizations have undertaken training programmes for their professionals at all levels to keep them in tune with the latest development.

Government has taken a very positive step to use computers in all government organizations. Training programmes for the users have been undertaken. Government departments, and organizations have a lot of potential for software deployment and thus ready demand has been created to attract many companies in the software business.

Government has also imported super computers and other latest devices for meteorology and defence related work. This gives a platform for development and dissemination of higher order computer skills.

A last issue, before leaving this topic, is of how industry itself perceives the benefits in export islands. On the fiscal side, respondents have invariably expressed satisfaction, confirming that these incentives were, in most cases, critical to their continued operation.

It is in the area of procedures,though, that there have been extensive complaints, mostly pertaining to the time and effort required for clearances. As regards facilities, complaints centre around the non-availability of cheap and reliable data communication links.

3.4 Industry Associations

The main industry associations connected with this industry are; the National Association of Software and Service Companies (NASSCOM), and the Electronic and Computer Software Export Promotion Council (ESC).

NASSCOM was set up in 1988, with the objective of promoting, developing, and protecting the interests of the software industry. NASSCOM's 150 and odd members represent approximately 90 per cent of the revenue of the software industry. NASSCOM has become useful as a focal point for the Government to interact with the industry. This is especially important as some of the software policy initiatives introduced over the years have been somewhat experimental in nature, and their success required a two communication between the government and industry.

NASSCOM has also served to coordinate international marketing efforts, and as a single point destination for international trade enquiries which have been directed to India, but without naming any specific firm. Such enquiries are distributed from NASSCOM, among its member organisations.

On the negative side, more than one of the smaller firms in this survey have talked of "large firm" domination of entities like NASSCOM, and complained of comering of international enquiries.

ESC was established by the Ministry of Commerce as a nodal agency to promote the export of electronics and software. It provides the government a medium through which it can interact with exporters in preparing promotional schemes and operating guidelines. ESC also provides consultancy services to firms with export potential (Hanna, 1994).

4. Survey Methodology

To start with, 18 firms were selected from industry surveys published in the literature (various issues of Dataquest) with six firms in each of three categories, small, medium, and large. The category was based on the number of employees as given in the literature.

A larger number of firms were selected for a mail survey.

Eighteen firms in the first list were surveyed by administering the questionnaire through interviews. There were some changes to the original list since some of those initially selected did not respond. In addition, 26 responses were received to the mail survey, and the combined results were then subject to analysis.

In addition, TIs which appeared relevant to the software industry were identified, and as many as possible were interviewed and C-DAC, NCST, IIT, Bombay and Indian Institute of Science, Bangalore were visited. Complete data was, however, provided by C-DAC and NCST only which have been utilized in the statistical analysis. Nevertheless the qualitative inputs from the other two institutions were quite useful.

5. Findings: Statistical Summary of Responses

An analysis of the frequency distribution of responses yields valuable insight into the nature and behaviour patterns of the industry as a whole. A later section looks at some correlations between questions, in trying to predict TI usage patterns.

The question by question distribution follows, with conclusions.

1. Sizewise Distribution

Table 5.1
Sizewise Distribution

No of employees	No of firms (interviews)	No of firms (mail survey)
< 50	6 (33.3%)	16 (66.67%)
51 - 100	3 (16.67%)	6 (25%)
101-300	3 (16.67%)	
101-1000		1 (4.2%)
301-500	3 (16.67%)	
501-1000	2 (11.1%)	
>1000	1 (5.6%)	1 (4.2%)
Total	18	24

Conclusion : While the interviewed firms were selected to be in different categories, the mail order firms were selected only by name, so that the responses give some idea of the industry's size

distribution. It can be seen that the industry is numerically dominated by small firms, and only one firm in each section had more than 1000 employees.

2. Agewise Distribution

Table 5.2
Agewise Distribution

Age (years)	<5 yrs	5-10	10-25	25-50	>50	Total
No of firms (interviews)	6	5	7	0	0	18
No of firms (mail survey)	17 (65.4%)	9 (34.6%)				26

Conclusion : This confirms the earlier assertion that the bulk of the industry dates back to the time after the departure of IBM in '77 and the introduction of indigenous microcomputers in '79.

Of the seven firms in the 10-25 year range, only three, Firms 01, 05 and 10 were founded before 1977. Of these, Firms 01 and 10 were (and are) also involved in hardware related activities, and considering the small size of the software market before 1977 it is likely that software, for both, was a later development.

The majority of the mail survey firms were even younger, less than five years old, and none in that category exceeded 10 years of existence.

3. Ownership Distribution

Table 5.3
Ownership Distribution

	No of firms (interview)	Total Capital (Rs)
Family	6	4.46 Cr
Group of friends	5	> 55.1 L
Public, dominant shareholders	3	> 15.45 Cr
Part of conglomerate	1	N/A
Foreign Jt venture, no government	2	161.4 Cr
Private and foreign large MNC	1	N/A
	No of firms (Mail survey)	
Private sector, domestic capital	22	
Private sector, foreign capital	4	

Conclusion: Numerically, software is not an industry dominated by the large firms, or even by public limited corporations. In fact, given its extremely low entry level capital requirements and its reasonable returns, software is often the field of choice for would be entrepreneurs, and a large number of small firms characterise the field.

However, the bulk of the capital and hence the resources is concentrated among the few bigger players.

4. Distribution by Type of Founder

Table 5.4
Distribution by Type of Founder

	Engineer	General entrepreneur	Corporate Origin	Academic Person	Total
No of firms (interview)	7	4	6	1	18
	Engr/Scientist as CEO	Others	Total		
No of firms (mail survey)	16	10	26		

Conclusion: Obviously, one does not have to have a technical background to start a software firm, though the percentages of firms headed by such people are probably higher than in less technology intensive industries.

5. Distribution by Rate of Sales Growth

Table 5.5
Distribution by Rate of Sales Growth

	Moderate	Rapid	Phenomenal	Total
No of firms (interview)	3	8	2	13
	Moderate to rapid	Rest	Total	
No of firms (mail survey)	20	6	26	

Conclusion: With virtually the whole industry growing from scratch (a period when growth rates are at their highest, since starting values are low) over the past decade, growth rates that may look phenomenal in older industries are considered normal.

What is significant is that there have been no cases, in either section of the survey, of declining or negligible growth. This is not to imply that software firms do not decline or fail - they do, and with a reasonable frequency. What does happen, though, is that the decline tends to be as rapid as the growth. Programmers quickly find other jobs, and, with few capital assets to dispose of, the shutdown can be quite rapid. Therefore, it would be difficult to catch such a firm in the survey.

6. Distribution by Total Sales Value

Table 5.6
Distribution by Total Sales Value

Sales Value (Rs '000)	No of firms ('92) (mail)
< 2500	6
2500 - 10000	8
10000 - 100000	9
100000 - 500000	-
> 1000000	1

Conclusion: The numerical majority (mail survey) are at the lower end, as is confirmed by the size based distribution. Interviewed firms were selected by research design and hence have not been considered for this analysis.

7. Distribution by Technical Expenditure

Table 5.7
Distribution by Technical Expenditure

Tech Exp as percentage of sales	No of firms (interview)
< 1	2
2 - 5	5
5 - 10	3
> 10	5
Total	15

The mail survey showed that 68% respondents had more than 5% (of total sales) of R&D expenditure while 52% had more than 5% in technical training expenditure.

Conclusion: The mail survey figures were in contrast to R&D and technical training expenditures in sectors other than software, where the majority had expenditures of less than 1% in both categories. This would seem to confirm the technology intensive nature of the software industry. Another section

of this report has a more detailed look at technical expenditures, attempting to correlate them with firms' perceived dynamism.

8. Distribution by Number of R&D Staff

Table 5.8
Distribution by Number of R&D Staff

No of staff	No of firms with that many R&D staff	No of firms with that many tech staff
0	6	2
<10	4	2
10-25	6	1
25-50	0	4
50-100	1	4
100-250	0	0
Total	17	15

Conclusion: There seems to be no hard and fast rule regarding technical staff strengths which applies to the industry as a whole. These numbers are, presumably, decided by local factors.

9. Distribution by Market Share

Table 5.9
Distribution by Market Share

	Domestic (interviews)	Domestic (mail)	Export (mail)
Insignificant	6		
Small		8	
Minor		47.6%	67%
Important	3		
Dominant		38%	One
Total	17	85.6%	---

Conclusion: These findings, too, are completely in consistence with the view of the industry as comprising a large number of small firms, none with any substantial market presence.

10. Distribution by Export Sale Percentage

Table 5.10
Distribution by Export Sales Percentage

% of export sales	No of firms (mail survey)
0 - 5	1
5 - 25	8
25 - 50	3
50 - 100	10

Conclusion: Egged on by attractive fiscal incentives, and with competitive advantages accruing from India's low cost skilled labour, the industry seems to be in exports in a big way. Some of the respondents in the last range could be 100% export units.

11. Distribution by Export Market Type

Table 5.11
Distribution by Export Market Type

Export market	No of firms (interview)
Industrialised countries	6
Developing countries	8
Both	3
No exports	0
Total	17

Conclusion: This seems to indicate that, while the bulk of the industry is exporting, not many are diversified exporters. In fact, though this table does not show it, a large number export to just one or a few foreign partners. In international marketing and overall global presence, the industry has still not arrived.

12. Distribution by Degree of Competition Faced

Table 5.12
Distribution by Degree of Competition Faced

	No of firms (Interviews)
Average or less domestic competition	7
More than average domestic competition	8
No domestic competition	1
Avg or less domestic competition from foreign firms	12
More than avg domestic competition from foreign firms	2
No domestic competition from foreign firms	2
Avg or less export competition (importing-country cos)	8
More than avg export competition (importing-country cos)	8
No export competition (importing-country cos)	1
Avg or less export competition (another-country cos)	5
More than avg export competition (another-country cos)	11
No export competition (another-country cos)	1
Avg or less export competition (various-country cos)	10
More than avg export competition (various-country cos)	5
No export competition (various-country cos)	2

In the mail survey, 68% of the firms faced high international competition while only 30% faced high domestic competition.

Conclusion: Note that the word "average" as used here does not refer to the mean of the respondents' replies, but to a value of 3 on a 1 to 5 scale - if the respondent gives a rating of 4, it is considered "above average".

What do these results tell us?

One, that foreign firms may find it difficult to compete in the Indian domestic market - almost nobody rates them as effective competition. The main reasons for this, as cited by respondents in interviews, were high prices and rampant piracy. Imports were confined to specialised high value packages only. Also, low labour costs, which is what gives India its export advantage, works against imports - there are probably no foreign firms which develop custom software for Indian clients - even though such development is immune to piracy.

Where the playing field is more level - against domestic competitors and in the international market - competition is more evenly distributed, as one may expect. The fact that there are firms with less than average competition internationally may mean that there are no inherent international roadblocks for Indian firms - or it could mean that some firms sell exclusively to foreign partners (the "no competition" respondents almost certainly belong to this category) passing along the problems of competition to them.

13. Distribution According to Existence of Geographic Cluster

54% of mail respondents indicated the existence of a cluster of (software) firms in their vicinity. The rest had no such cluster.

Conclusion: The fact that almost half the firms (of a reasonably random sample) were located within clusters indicates that a degree of clustering does characterise the industry, and some of this would be due to the existence of software technology parks and similar Government supported groupings.

14. Distribution According to Self-perceived Technology Leadership

Twentysix of 27 mail survey respondents rated their technological capability to be the same as the domestic leader's while only one rated itself as very low compared to the leader.

As compared to the world leader, 46% of the respondents rated themselves as average while 46% rated themselves comparable.

Conclusion: Had it not been for the international ratings, this would simply confirm that software professionals have big egos, since, obviously, leadership variations must exist in practice!

More likely, this has to do with the nature of the work done by Indian software industries. As of date, no product originating from India has received wide international acclaim and no Indian software house has a big presence in international media advertisements.

Whatever innovation does take place, therefore, is not well publicised, and the resulting image would be one of good workmanship, reasonable costs, and other such factors, where it is easy for anyone to feel that he is doing as good a job as any other. The absence of any kind of software certification and product rating system also means that there is no way to really establish who is doing a better job.

The difficulty here is to establish congruent definitions of leadership in the minds of surveyor and respondent.

In international ratings, also, there seems to be a "two state" situation - average and comparable. A factor that may be at play here is the relative ease with which software products - almost any product - can be "cloned". The key to product success then lies in marketing and a respondent who does not realise this, but merely compares his work on technical grounds will find himself comparable to world leaders. As a matter of interest, many of the world's leading packages - spreadsheets, word processors, and the like - have been cloned at some time or the other in India. Commercial software varies according to country conditions making it yet more difficult to establish product superiority.

15. Importance of Sources of Competitiveness

Table 5.13	
The mean importance of sources of competitiveness (interviews)	
Product quality	3.94
Product design	3.76
Product reliability	3.88
Short delivery time	3.59
Lower price	3.94
New product development	3.29

Conclusion: Table 5.13 shows that except for "new product development" which is rated at 3.29 all the remaining factors are considered to be quite important. Even though each individual firm would be expected to utilise a set of factors unique to it on the average in the industry there would be atleast some firms using each of the factors.

To take a contrasting case, suppose no one had rated, say, low price, as an important factor. That would have indicated that the Indian software industry was a high cost island, focusing only on cost insensitive products.

16. Distribution by Tech Dynamism of Product/Process Changes

Table 5.14
Distribution by Tech. Dynamism of Product/Process Changes

Technological Dynamism	Product Changes [No. of Firms (Interviews)]		Process Changes [No. of Firms (Interviews)]	
	Incremental	Significant	Incremental	Significant
Stagnant	4	1	4	1
Very slow	0	0	1	1
Moderate	10	10	11	14
Rapid	2	3	1	0
Exceedingly Dynamic	1	3	0	1
Total	17	17	17	17

Conclusion: Moderate change is what marks the industry as a whole, which is more or less what one would expect, given that the Indian software industry is neither exploding, nor is it in decline.

17. Distribution of Sources of Product/Process Change

The results (interview) were :

a) Significant Product Changes

* 18 significant product changes had taken place.
* 8 product changes had taken place through TI.
* Only 1 product change had taken place through foreign collaboration support.
* 9 product changes had used only in-house support.

b) Incremental Product Changes

* 16 incremental product changes had taken place.
* Of which, 14 were solely in-house.
* The other 2 had taken help from TIs.

c) Significant Process Changes

* 14 significant process changes had taken place.
* Of these, 8 had taken TI support, while,
* 5 were done in-house.
* Only 1 used foreign collaborator support.

d) Incremental Process Changes

* 12 incremental process changes had occurred, of which,
* 6 used TI support, and,
* 5 were done in-house.
* Only 1 used foreign collaborator support.

Conclusion: Given that a good proportion (in all categories of changes) were done in-house, while an equally good proportion used TI help, one cannot assert either that Indian software firms ignore TIs or, at the other extreme, totally depend on TIs.

18. Importance Attached to Confidentiality/Protection (Interview):

Confidentiality	:	4.33
Protection of new technologies	:	4.40

Conclusion: Given that all firms would be possessive about new technology in which they had invested, one may have expect universal ratings of 5. But, surprisingly enough, lower ratings were obtained in some interviews. On being asked to explain, respondents either said that (a) they assumed that TIs were so ineffective that they would not give them critical technology anyway, or (b) they had no experience in the matter, and, a-priori, did not feel the issue would be all that critical.

19. Organising of Inter-Firm Links (Interviews)

The results were :

Four out of 17 firms had links with other firms for minor/major product/process changes with contributions rated high.

Across all four categories, though, a TI was cited only once as helping to organise inter firm links. This was for a minor product change, and the TI's contribution was rated average.

Conclusion: One may conclude that firms do not look to TIs when they wish to work with other firms.

20. Collaborations with Institutions

Table 5.15
Collaboration with Institutions

Institutions	No of firms	Mean contribution
Industry association	3	4
Research association	1	
General R&D institution	1	
- Private	0	
- Public	4	3.33
Specialised R&D institution	1	
Technical colleges	3	
Private consultancy	2	

Conclusion: What is noteworthy is the diversity of sources of collaboration - every source has been used by someone. But the main sources seem to be the traditional ones - technical colleges and public R&D. Industry associations are also made use of.

21. Usage of External Organisations

Table 5.16
Usage of External Organisations by Interviewed Firms

Non TI Organisations	Frequency of Usage (of firms for membership)
General association	6
Industry specific association	19
Specialised organisation	2
Industry specific organisation	8
Research organisation	0
Fully integrated institution	0

TIs	
General association	2
Industry specific association	3
Specialised organisation	5
Industry specific organisation	11
Research organisation	1
Fully integrated institution	4

Table 5.16 contd.)
Usage of External Organisations (Mail)

Organisation Type	Used by no of firms (mail)	Rated above avg imp by no of firms (mail)	Important benefits	Important problems
			(NPD=New Prod Devlpmnt)	
1) Private contract R&D	2	1		
2) Long term customers	9	6	Ideas (5) NPD (5)	
3) Long term suppliers	11	6	Quick (5) Solutions (6) Ideas (4) NPD (4)	Timeliness (4)
4) Dept/Lab	7	7	Quick (3) Solutions (3)	
5) Foreign investor	5	4	Quick (4)	
6) National Tech Inst	7	2		
7) Local/Regl Tech Inst	3	0		
8) Consulting firms	13	5	Ideas (7) Solutions (5)	High fees (6)
9) Universities	8	3	NPD (5)	Timeliness(4)
10) Educational Association	12	4	Quick (5) Contacts (6)	Tech. Unable (4)
11) Academic Association	2	1		
12) Research Association	2	1		

Conclusion: From the interview results, it appears that industry association membership is regarded as the most important, these having the highest interaction. Nothing very definite can be said regarding the rest.

Mail survey results show where firms are more likely to go more often - either to their long term customers/vendors or to a consulting firm.

The academic establishment (institutes, universities, educational associations) are all characterised by a high usage rate and a low importance rating. At first sight this would seem to indicate that a lot of firms approach these traditional sources of knowledge, only to encounter subsequent disappointment.

What is really surprising is the "timeliness" problem associated with long term suppliers. One would have expected vendors, to be particularly responsive to their buyer's needs! But at the same time, they have been cited for the maximum types of benefits (including "Quick" - showing that not all vendors delay) - which is probably why they continue to remain vendors!

22. Usage of Benefits from External Organisations (Interviewed Firms)

Table 5.17
Usage of Benefits from External Organisations (non-TI) by Interviewed Firms

Benefit	Frequency of usage
Seminars/workshops	8
Information	8
Advice	0
Worker training	6
Testing services	1
Liaison	16
No benefits	10

Table 5.18

Benefits taken from (TI and non TI) external organisations

Benefit	Interview			Mail	
	Usage Freq	Mean use freq	No of firms	No of firms With >avg imp.	Major sources
Info/lib services	7	2.53	14	10	LT spplr (4)
Problem solving/troubleshooting		1.53	10	6	LT spplr (4) Cnsltg firm(4)
Software/database	3				
Consulting	4				
Testing to standards	2	1.41	10	7	LT csumr (3)
Quality certification	1				

Table 5.18(contd)

Benefit	Interview		Mail		
	Usage Freq	Mean use freq	No of firms	No of firms With >avg imp.	Major sources
Seminars	6				
Education/training		1.94	16	11	Cnsltg firm(6)
Contract R&D			1	1	
Collaborative R&D			5	3	
Applied R&D		1.35			
Strategic R&D		1.47			
Project devp cycle	1				
Product engineering	1				
Engineering services		1.47			
Mfg products		1.29			
Commrcl/mngrl advice		1.53	11	4	Cnsltg firm(6)
Technical networks			13	6	Indl Assn(6)
(Note : LT means "long term").					

Conclusion: This data can serve as a checklist of what services are sourced externally by Indian firms. Library access, courses, and consultancy - the traditional ones - figure prominently, but software/ database access (in many cases, this refers to NCST's E-Mail and software bulletin board facilities) have also had reasonable usage.

Services like contracted out R&D and testing to standards occur less frequently, but that is only to be expected, as these activities, associated with product development, do not occur all that often in the workings of the average company unless it is itself a dedicated R&D house, in which case it is more likely to have the relevant services in-house.

Going for commercial and managerial advice is a lot more frequent. This, too, is only to be expected. In an industry that is characterised by small firms, the average firm is more likely to go out for such services,than to maintain full time lawyers, market researchers, and the like, in-house.

23. Usage of Outside Consulting

Table 5.19
Usage of Outside Consulting

	Used by no of (interview) firms	Mean (1 to 5) Contribution
Pvt. consulting firms	8	3.75
Individual consultants	6	4.17

Conclusion: (1) Use of consultants is quite common and (2) those who do use consultants are quite happy with them.

24. Sources of Training

Table 5.20
Sources of Training

Source of training	Used by no of (interview) firms	Mean Contribution
Vocational Institutions	4	3.5
Industry association	6	3.67
Universities	9	3.78
Jt Venture partners	5	3.20
Buyers	3	4.33
Suppliers	4	3.5

Conclusion: It is the more or less even distribution that may be surprising, if one considers that only two of these (universities and vocational institutions) are "traditional" sources of training. The fact is, software is characterised by high customisation of products. Even a lowly financial accounting package can be difficult to use "out of the box" - a quick course on it at some point may be useful.

While universities still have the highest rating, vocational institutes have not fared as well while industry associations have high ratings. The last two may be due to the need for specialised courses. We are talking here of the software industry and not the users who will need specialised, rather than run of the mill, courses, which they are less likely to find in vocational institutes. The latter would probably conduct more conventional courses on regular schedules.

Why do buyer conducted courses have such a high rating? Of all the parties listed here, the buyer has the biggest stake in making sure that what is taught really gets across - otherwise there will be the risk of not getting what has been paid for. An organisation which conducts a course in the role of a buyer would naturally do so in order to explain the requirements pertaining to some complex or specialised software which has been ordered.

24. Who Employs Departing Employees?

According to the (interview) firms, related industrial firms and technical colleges/universities were significant employers (mean significance 3.35 and 2.24 respectively) of their employees who left in the last 3 years.

Conclusion: In other words, someone leaving a software firm will go either to another job, or for higher studies.

25. Impact of Government Policies

Table 5.21
Impact of Government Policies

Policy	Used by no of firms (intrvw)	Mean impact (intrvw)	Used by no of firms (mail)	No of firms rating the Policy as above avg
Fiscal incentives	7	4.29	15	9
Grants	4	3.5	2	0
Special tech loans	3	3.33	1	1
Training incentives	2		3	1
Govt procurement	1		1	0
Standards/Testing	3	3.33	4	1
Market Protection	0		0	0
Export Incentives	13	4.31	16	10

Conclusion: Fiscal, and export incentives have obviously had the greatest impact, as was discussed in an earlier section. Grants, special technology loans and standards/testing facilities have not been used very much but those who have availed of them have rated them to be of above average impact.

26. Future Needs

Table 5.22
Future Needs

Need	Frequency of need (intrvw)	No of (mail) firms citing need
Info/Lib network	6	
Software/Database	5	
Testing/Standards	3	
Process engineering	2	
Product engineering	3	
Commercial advice	1	
Equipment/machinery	4	2
Financial resources	6	11
Human resources	2	5
Environmental scans	2	4
Govt policy	7	12

Conclusion: The greatest needs are in the areas of library and database facilities (traditionally sou from outside), and in financial resources (always critical to a firm) and government policy (wh despite liberalisation, continues to play a major role). As the future needs of industry form a signific part of the study, a later section provides a detailed listing of interview respondents' "wish lis Surprisingly human resources did not figure as a major "need", though the software industry considered to be suffering from acute shortage of qualified personnel.

6. Findings : Correlation Between TI Use and Size/Dynamism/ Manageme

This section attempts to find the effects of certain factors on TI usage. Analysis is confined to the 1 firms which were interviewed.

a) Characterisation of Respondents by Size

Table 6.1
Firm Employee Strength

Firm No. (Code)	No. of Employees
01	48
02	290
03	215
04	1100
05	4000
06	40
07	80
08	950
09	26
10	270
11	87
12	311
13	110
14	12
15	350
16	28
17	95
18	25

When starting the survey, size (as determined from literature or from other sources) was the determinant used to create three categories, small, medium, and large. However, a look at the actual sizes (arranged in ascending order of size in the list below), shows eight distinct clusters of similar sized firms.

The clusters can be used in order to characterise size.

Cluster I

14 : 12

Cluster II

09 : 26
16 : 28
18 : 25

Cluster III

01 : 48
06 : 40

Cluster IV

07 : 80
11 87
13 : 110
17 : 95

Cluster V

03 : 215

Cluster VI

02 : 290
10 : 270
12 : 311
15 : 350

Cluster VII

04 : 1100
08 : 950

Cluster VIII

05 : 4000

b) Characterising Dynamism

An assessment of technology dynamism is necessarily subjective to some extent. Given that constraint, the respondents' dynamism on a 1 to 5 scale can be rated as follows (reasons have been given for each assessment). Next, as a cross check on the subjective judgement, the ratings are correlated to training technical expenditures, which will to an extent, indicate overall dynamism.

Table 6.3
Technology Dynamism of Interviewed Firms

Firm Code	Rating	Remarks
01	5	High tech products
02	3	Products are not especially high tech
03	4	Technically advanced products
04	5	Wide range of technological diversified projects
05	5	Wide range of technological diversified projects
06	2	More emphasis on management than on technological innovation
07	3	The CEO is dynamic but the organisation has still not moved significantly away from its body shopping roots
08	2	The parent, a US based multi- national is the source of most technology
09	5	Innovative projects
10	3	Couple of reasonably innovative development projects
11	4	Innovation more in their tools, not products
12	3	More emphasis on project management than technology
13	2	Technology from British parent
14	5	Company has gone up on product innovation
15	4	Good range of projects, especially in the past
16	5	Company has gone up on product innovation
17	3	More emphasis on agency business
18	4	Reasonably innovative products

How does the above correlate with training expenditures as a percentage of sales? In the list below, the firms have been ordered in ascending sequence of dynamism and the technical expenditure percentages have been given alongside. (Where a range has been given, such as 13% to 14%, the midpoint - 13.5% - is taken).

Table 6.4

Firm Code	Rating of Tech. Dynamism	Tech. Exp. as % of Sales
01	5	71.43%
02	3	7.2%
03	4	4.3%
04	5	5%
05	5	23.0%
06	2	2.0%

07	3	6.0%
08	2	13.5%
09	5	77.5%
10	3	0.5%
11	4	2.5%
12	3	5.1%
13	2	4.0%
14	5	12.8%
15	4	7.7%
16	5	19.2%
17	3	46.7%
18	4	36.4%

There is, obviously, some correlation evident - many of the firms lower down in terms of technological dynamism have single digit expenditures. But do we account for the exceptions?

In Firm 08 case, there is evidence that much of the expenditure has been on buying technology including training by expensive from its US based multinational parent co. Their training expenditure is 10% of sales and R&D and technical services budget 3 to 4 %. They themselves acknowledge that most of their technology inputs come from the parent.

Firm 17 is an apparent anomaly - Rs 7 million of R&D on Rs 15 million of sales! The explanation probably lies in recent product development, which has led to the big expenditures, but the sales from which are yet to materialise.

In the '4' and '5' categories, the low spenders are; Firms 03, 11 and 15.

Firms 03, 11 and 15 have all stabilised their product lines. In all three cases, the rating of 4 was based on past product development activities, so there is no inconsistency.

In Firm 04's case, the respondent later clarified that the 5% referred to R&D alone, explaining that "technical services" characterise practically all company operations, which would boost the figure to close to 100%.

Firms 01 and 09, both technological "hothouses", have predictably high figures (as Firm 04 would also have had, had the respondent classified expenditures in the appropriate manner).

In short we can conclude that there is some justification for these subjective ratings of technological dynamism.

c) Characterising Management Behaviour

Characterising the management's behaviour pattern as distinct from whatever formal equity structure the firm has, could be done along two dimensions :

1) Does top management provide Hands-on-technical leadership as opposed to concentrating on managerial systems and controlling their engineers through budgets and related controls?

In a software company, this could roughly be estimated by how often top management actually sits at a keyboard for development related work - though not necessarily for actual development.

2) Did the managerial systems - policies and procedures - currently in place evolve over the life of the organisation or were they acquired from a parent?

A good indicator here would be the question of who has designed the forms in use. If the payslip, or the expense account form, or the leave application form, has been designed by the incumbent top management, it is an organisation with "home grown" systems.

3) A third determining factor is whether a firm's technology agenda is market driven or joint venture partner driven. The survey did not throw up any other patterns - there was not a single firm surveyed whose product choices were determined by any agent other than customers or partners.

The age of each firm has also been given as a reference.

The classification of survey respondents along these lines is : (this assessment, also, has to be somewhat subjective).

Table 6.5
Some Characteristics of Management Behaviour

Firm Code	Tech Leadership	Evolved Systems	Market Driven Tech. Agenda	Age in '92 (yrs)
01	No	Yes	Yes	19
02	No	No	Yes	5
03	Yes	Yes	Yes	6
04	No	Yes	Yes	14
05	No	Yes	Yes	24
06	Yes	Yes	Yes	1
07	No	Yes	Yes	5
08	No	No	No	4
09	Yes	No	No	3
10	No	Yes	Yes	20
11	No	Yes	Yes	12
12	No	Yes	Yes	10
13	No	Yes	No	4
14	Yes	Yes	Yes	9
15	No	Yes	Yes	11
16	Yes	Yes	Yes	4
17	No	No	Yes	10
18	Yes	Yes	No	2

Conclusion:

d) **Characterising TI Usage**

Some indicators of the use of outside help (TIs as well as others) are:

1) Expenditures on subcontracting training and services.
2) Involvement of outsiders in product and process changes.
2) Sources of training.
3) Usage of non-training services (including tech collaboration).
4) Usage of private consulting firms or consultants.

In the data below, a * has been used to show where a TI is used. (Note, where a TI, as well as a non-TI have been separately utilised for the same service, only a single entry with a * is given. For training, though, numbers of people, where available, have been shown separately for the two categories).

These are then used to arrive at a subjective rating for outside organisation and TI usage, for use in investigating correlations.

Table 6.6
Firm-wise Indicators of Use of Outside Help
*(A * is used to indicate TI usage)*

Firm Code	Subcontract %age	Outsiders involved	Outside training	Other services	Consultant Usage (1-5)
01	Nil	None		*Info -Probsolvg -Standard -Commtcl -StarRes	-Collab
02	5.2%	Product Major		-Standards -Tmg -Engg serv -Mfg pro -Commrcl -Datacom -Collab	4, 5
03	Nil	None		*Standards *Tmg -Info *Collab	4
04	Insigni-ficant	Product Major Product Minor Process Major Process Minor	*1% of people 2% of people	*Library *Software -Testing -Certifctn*Research *Services (includg commrcl) *Collab	5

Firm Code	Subcontract %age	Outsiders involved	Outside training	Other services	Consultant Usage (1-5)
05	2.6%	Product Major *Process Major *Process Minor	51 people *5 people	*Library -Software *Consultg *Trng *Collab	4
06	Nil	None	55 people	None	None
07	Insigni-ficant	Process Major	*2-3 people	*E-mail -Seminars *Collab	None
08	Nil	Product Minor Process Major	35 people	*Collab	4 but all in non- technical areas
09	2%	Process Major	15 people *4 people -In-house seminars	*Software *Collab	4
10	0.375%	Process Major *Product Minor Process Major Process Minor	*6 people 52 people	-Library -Consultg -Devpmnt -Research -Commercl	3
11	1%	Product Major *Process Major	6 people *6 people	*Library *Seminars	5
12	0.12%	Process Major Process Minor	39 people *3 people	*Library *Seminars -Standards -Commrcl	3
13	0.6%	Process Major Process Minor	50 people	-Certfctn	None
14	2.86%	Product Major Process Minor	6 people	-Software -Seminar -Collab	5
15	Nil	Process Major	None	-Consultg -Commercl	3
16	Nil	None	None	None	None
17	13.8%	Product Major	None	-Seminars	None
18	1.1%	Product Major	*2 people	None	2

The next step is to assign each firm a "figure of merit" for the use of outside help, as well as one for TI interaction. The simplest way is to simply allot one point for each of the five headings above, if the firm has anything in that area. This will yield ratings on a 0 through 5 scale for outside help and from 0 through 3 for TI interaction, with 0 being the lowest.

The two tables below show these ratings, along with all the factors being investigated, from the other tables. One is in the ascending order of the outside usage rating, the other in the ascending order of the TI rating.

Table 6.7
Correlating Propensity to Use Outside Help and TIs
With Different Characteristics
(Inn Order of Outside Help Rating)

Firm Code	Out use	TI use	Size (empl)	Cluster	Dynamism	Tech Ldrshp	Evolved Systems	Market Driven	Age '92 (yrs)
01	1	1	48	3	5	No	Yes	Yes	19
02	4	0	290	6	3	No	No	Yes	5
03	2	1	215	5	4	Yes	Yes	Yes	6
04	4	3	1100	7	5	No	Yes	Yes	14
05	5	3	4000	8	5	No	Yes	Yes	24
06	1	0	40	3	2	Yes	Yes	Yes	1
07	3	2	80	4	3	No	Yes	Yes	5
08	4	1	950	7	2	No	No	No	4
09	5	2	26	2	5	Yes	Yes	No	3
10	5	2	270	6	3	No	Yes	No	20
11	5	3	87	4	4	No	Yes	Yes	12
12	5	2	311	6	3	No	Yes	Yes	10
13	4	0	110	4	2	No	Yes	No	4
14	5	0	12	1	5	Yes	Yes	Yes	9
15	3	0	350	6	4	No	Yes	Yes	11
16	0	0	28	2	5	Yes	Yes	Yes	4
17	3	1	95	4	3	No	No	Yes	10
18	4	1	25	2	4	Yes	Yes	No	2

Note: For "Outside Help" the scale varies from 0 to 5 and for TI use the scale varies from 0 to 3.

Table 6.8
Correlating Propensity to Use Outside Help and TIs
with Different Characteristics
(In Order of TI Interaction Rating)

Firm Code	Out use	TI use	Size (empl)	Cluster	Dynamism	Tech Ldrshp	Evolved Systems	Market Driven	Age '92 (yrs)
01	1	1	48	3	5	No	Yes	Yes	2
02	4	0	290	6	3	No	No	Yes	5
03	2	1	215	5	4	Yes	Yes	Yes	20
04	4	3	1100	7	5	No	Yes	Yes	14
05	5	3	4000	8	5	No	Yes	Yes	6
06	1	0	40	3	2	Yes	Yes	Yes	9
07	3	2	80	4	3	No	Yes	Yes	4
08	4	1	950	7	2	No	No	No	4
09	5	2	26	2	5	Yes	Yes	No	3
10	5	2	270	6	3	No	Yes	Yes	5
11	5	3	87	4	4	No	Yes	Yes	10
12	5	2	311	6	3	No	Yes	Yes	11
13	4	0	110	4	2	No	Yes	No	12

14	5	0	12	1	5	Yes	Yes	Yes	4
15	3	0	350	6	4	No	Yes	Yes	10
16	0	0	28	2	5	Yes	Yes	Yes	6
17	3	1	95	4	3	No	No	No	1
18	4	1	25	2	4	Yes	Yes	No	24

Note: For "Outside Help" the scale varies from 0 to 5 and for TI use the scale varies from 0 to 3.

Conclusion: In neither table does visual examination show any pattern of the type that may indicate a correlation for any of the individual columns. (Such a pattern would be a reasonably steady ascent or descent.) In other words, none of these factors, taken in isolation, is sufficient to predict TI usage or outside usage.

This exercise has been useful because it seems to indicate that a firm's propensity to seek outside or TI help is not simple function of factors like size, technological leadership, or its being part of a cluster, etc. More likely, it is a complex phenomenon, with perceptions and other intangibles playing a part.

7. Findings : Other Reasons for TI Usage/Non-Usage

Other than management style, size, and dynamism, what else could determine the nature and extent of a firm's TI usage? Many factors were stated by respondents, and are listed here. The next section subjects some of these statements to scrutiny and analysis, and also brings out some interviewer perceptions of things which were not stated by respondents.

7.1 Reasons for Firms Using TIs

a) The presence of a "frontier technology" component in the business. Thus, the joint ventures between Firm 04 and Firm 05 and certain universities in areas best classified as "research".

b) The need to bring in professional management systems. The majority of companies adopting SSAD, for instance, started with one or more courses, which could be from a TI.

c) The need to upgrade their own technology. This was heard more from technology driven companies, who, when going into new areas, often looked around for outside help.

d) TIs were used for services whose usage volumes were not sufficient to justify having them in-house (libraries or testing facilities come to mind).

e) A related need was for services - such as E-Mail which just could not be provided in-house.

7.2 Reasons for Firms not Using TIs

a) Export oriented companies tended to feel that local TIs have out-of-date or irrelevant technology. This was heard from companies (such as Firm 09) for whom technology is a key part of their export offering. This is probably justified, for the simple reason that such technologies would not be particularly relevant in India and Indian TIs cannot justify tying up their resources in supporting them. Firm 09, for instance, is an export unit and is concerned with sophisticated communication and internetworking products, with only remote relevance in the Indian context.

b) Inadequate publicity of TI services. The case of Firm 16 is a good example whose CEO (the respondent) felt aggrieved that he was not even aware that NCST (a TI in which he was interested) had a branch in his city.

c) Cost and quality. This covers several aspects. Small companies, preoccupied with returns on every bit spent, were concerned with direct costs, while others were worried by what they felt was a lack of "industrial orientation" on the part of TIs - time and manpower required for the initial orientation, delays due a lack of urgency on their part, and a fear that TIs would be more concerned with theoretical correctness than with relevance to the customer.

d) Companies with joint venture partners tended to always prefer them as technology sources, and, in most cases, did not even investigate whether comparable technology was available with a TI or anywhere else.

e) Lack of relevant technology. For instance, when Firm 12 set about developing their first CASE tool version, they approached NCST for help, but the latter had nothing to offer. Unfortunately one could not find out NCST's side of this particular case, but one may suppose that it is a classic "chicken and egg" problem - NCST will not invest in the technology unless someone from industry first shows interest, and the latter will not push the matter if the TI has nothing to offer.

f) A perceived organisational (as opposed to individual) lack of interest on the TI's part. One respondent from Firm 05 said in effect that "While individual professors work with us, the institutions do not see us as a part of their plans".

g) Lack of familiarity with contemporary software management practice.

7.3 TI Services Used

The most heavily used were courses, along with facilities like library and E-Mail services.

Next came contract design and joint development projects.

There was also some usage of certification related services.

8. Some Explorations : Firm Perspective

This section goes into latent reasons, impressions, even conjectures. Naturally, most of it is subjective, and not arrived at through any kind of statistical analysis. Apart from the question of completeness, there is one important reason for considering hidden motivations, which is that no marketing campaign can succeed without considering them.

But are such intangibles all that important in software?

In fact, many perceptive commentators have commented on the extent to which software development, an engineering discipline, is influenced by psychological factors. This is not as surprising as it may sound since software development, can be as creative as writing a book, and often requires similar thought processes.

This is, despite the fact that vast numbers of programmers are engaged in fairly routinised work. Much commercial software development - which constitutes the bulk of all development - is the adaptation of generalised tools to varying customer needs. But such activities, even if numerically dominant, are

not the focus of those studying and those managing the software industry. Also, over time, such jobs tend to get automated, with computers themselves doing the job formerly done by programmers. The whole history of software has been one of ever decreasing "lines of code" - i.e. programmer output - to do a given job.

8.1 Some Hidden Motivations for TI Usage

A) To start with, consider the projects done by the industry giants in collaboration with universities.

Normally, when an idea originates in an academic institution and makes its way to industry, it does not do so through joint ventures. Academics have the skills and the time to develop theoretical aspects of an idea, but they are not the best people to even build real life prototypes. They lack testing facilities, they do not have a effective procurement structure in place, and they may not be able to put in the kind of hours that may be necessary to meet a customer deadline.

Yet, the two big firms both demonstrably well run companies, have not only chosen this apparently inefficient route, but have done so repeatedly. Why?

a) An obvious reason is the prestige deriving from association with reputed academics. They are both in exports, and, even now, Indian academics probably enjoy a far higher international stature than their counterparts in industry. Each time the companies try to make a sale, they are not only fighting the competition, but also scepticism regarding "third world" India as a source of technology. A professor with a foreign PhD and international papers to his credit can be a powerful ally. In fact, it would also be beneficial for them to associate with foreign academics, and both of them have done so.

b) An academic who successfully associates with a company over several projects will come to feel himself (or herself) to be a part of the company, and will get to exert a growing influence. This may help counter a problem all software companies face, which is a slackening of technical rigour in the face of deadlines. Shortcuts are taken, exceptions made, and, soon, sloppy technical practice becomes the norm, especially with new recruits.

c) Another possible benefit is that the academic can serve as a repository of techniques. It is not worthwhile for a practising programmer to remember ten ways of, say, sorting a disk file. He is much better off simply consulting the academic when he needs one.

In all the cases, the real benefits come through the association of the academic with the industry, the project(s) merely serving as a means. It would be difficult for the firm to get these benefits otherwise. This, however, does not imply that the projects themselves are of no intrinsic value. All such projects must have some value to the firm, so as to be sanctioned in the first place.

It is just that the Indian software industry (or, for that matter, all Indian industry), has never been noted either for long gestation R&D, or for path-breaking products. The vast bulk of their output has been the duplication or adaptation of existing products, and neither calls for extensive academic-style R&D.

Another significant indicator is that the associations are with individuals rather with their organisations. A respondent felt that this was because educational institutions tended to exclude - firms from their planning. But, the question remains as to what extent one of the firms, which already had influence with senior faculty attempted to get themselves included in that planning. It could at least have attempted to do so.

Had the emphasis been on the projects themselves, organisational contacts would make more sense - any project would benefit from institute level resource commitments. But, if the focus is on "general association" benefits, then individual links are preferable.

An exception is one of the large firms' association with C-DAC. C-DAC has developed pathbreaking technology to international standards - parallel computers developed by them have been sold to Universities in Canada and Germany - and the company is working with them to incorporate this technology in its computers. In this case, the links are fully at an organisational level, and the project's intrinsic worth is very much the key issue.

B) Next, consider the case of those going to TIs to learn **software management** practices (such as SSAD or ISO).

Perhaps, THE main reason is the need to be away from the office.

It is difficult to study SSAD books if one is liable to be called to the phone at any time. The way out is to either send people for a course, or to have an in-house course.

For this purpose, a TI is generally preferred to a commercial course. Not only is the "academic" atmosphere guaranteed, but there will also be a good library, and probably more computer time.

Another benefit is completeness of coverage. Academics are experts at assembling a syllabus. Finally, the prestige factor is present here too. It is useful to tell prospects that the staff were trained by a foreign Ph.D.

C) The next case is of technology driven companies who go to TIs to assimilate new technology.

Many respondents said that, at a certain stage, they wanted assistance from outside parties. The interesting thing, though, is that none of them got it. The reason for this is not that there is no agency competent to help. More likely, it is something else. Assimilation of new technology is not an easy process.

The problem is that,if two parts are interlinked, both have to be understood before either can be.

Assimilating new technology through published material is a matter of several iterations over the same material gets clearer. This is the time when the learner feels that the book does not present the principles properly, and that a good teacher could be of help. Often disappointment inevitably follows as this is not a situation where anybody can be of help.

Persons from one firm joined a C-DAC course and walked out, finding their standards too low. It was probably this predicament that drove them to join - after which they discovered how much progress they themselves had unconsciously made.

8.2 Reasons for Avoiding TIs

Here, too, some not so visible influences may be at play. Some of the complaints may be justified. Certainly Indian TIs may be technically not very relevant to export oriented units - as mentioned, the problem of low demand may prevent them from investing in relevant technology.

Inadequate publicity is also probable. TIs have not had much experience in self promotion, which is not common in the academic world. Similarly, prospective clients for software management skill

training may wonder whether, given the lack of a "live" environment, the TI itself will be able to develop the necessary skills.

The case of joint venture partners needs examination. Is an Indian subsidiary of an MNC justified in getting all its technology needs from its parent? For one thing, parent company's experts would certainly be much more expensive than, say, NCST's ones. Also, on issues like identifying local experts, familiarity with local software versions, and the like, NCST would have an edge over the MNC parent.

One thing that came out was that the Indian subsidiary's people were very conscious of being part of the world ranking company. The respondent emphasised that, functionally, they were a part of the MNC parent and not a "joint venture".

Could it be a prestige issue, a problem with admitting that the Indian JV partner was not self sufficient in technology? Could this, further, be compounded by a simple lack of awareness of the standard of the facilities available locally ? Let us suppose it is. The issue then is: How can a TI like NCST set about gathering Indian JVs into its fold?

One way could be to start getting involved in collaborative projects. In the interview, the Indian subsidiary of the MNC projected itself in the role of a technical messiah - they emphasised that they were organising groupings to help upgrade local industry.

Perhaps, NCST could involve in such groupings. Once in, the division of roles within the project will be hidden from public view, and NCST can try involving the company into paying for some of its services, possibly including their people in courses, and so on.

Take another case. This company gets its people trained at their JV parent's works but are not dogmatic about it - they have also got large numbers of people trained locally. In a case like this, a simple cost-benefit analysis is involved without extraneous factors. An institution like NCST can show advantages like local follow up.

But the biggest barrier seems to be "time and cost" issue. This barrier comes in the way of joint ventures, which can go far beyond classes in fostering links between TIs and industry - in a class the interaction is formalised, often (in India) one way, and confined to a couple of hours a day.

Respondents describe the problem with terms like "lack of an industrial orientation". What are the perceptions and the realities?

A very important factor is the perception in India of academics as ascetics. Dating back over centuries, and reinforced by countless cliche situations in movies and books, the teacher is supposed to be above sordid commercialism. From a respondent's perspective, this implies an ignorance of basic commercial principles, which could prove disastrous in a joint venture. Beyond that, academics are generally assumed to have a very relaxed lifestyle hence incapable of responding to deadlines.

There is the fear that they will go overboard in a quest for technical rigour. The real problem could be a lack of control.

There is also a question of motivation. Will an academic be interested in a project which does not lead to a publishable paper?

8.8 Some Guidelines for Meaningful Association

One is to clearly demarcate areas of academic and industrial competence - which is easy - and to convince industry that most projects need both - which may be a lot more difficult.

As regards attitude problems, perhaps one of the large firms surveyed for this study has found the best way, which is to make academics "part of the family", through a series of events. Over time, each side will come to see the other in a different light. In this case, the company took the initiative for such an association.

The TIs can also take certain initiatives. For example they can send mailers on courses and services, till the industry decides to send people for a class.

The next stage would be simple public relations - the company's senior management could be invited to give lectures which they may feel like reciprocating. That may at least get things started.

A later section is on problems that may prevail on the TI's side.

9. Findings : The TIs' Perspectives

The number of TIs covered by the survey was much less than the number of firms. This makes it somewhat more difficult to generalise for TIs. However, what was overwhelmingly apparent, was the difference in attitudes between first and second generation TIs.

A university is very clear that its primary mission is to impart knowledge and train people. That is how it serves the nation and will continue to do so. At IIT Bombay, or IISC, Bangalore all those interviewed were firm on this point - while they were proud of their interaction with industry, there could be no ambiguity on the basic mission itself.

On the other hand an NCST or a C-DAC will consider itself highly successful only when Indian industry's products - with NCST or C-DAC inputs inside - make it big on the national and international scenes. They are also clear on their status as national laboratories. So is an IIT, but with a subtle difference - it does not seem to see itself as a resource for direct end user utilisation.

Another difference is size. In an engineering college, say, it is possible for a lone consultancy cell to function in a sea of indifferent faculty members, but any kind of dissent in an NCST or a C-DAC will be noticeable at once.

IITs appear to be characterised by a commitment to industry interaction at the organisation level, not always matched at an individual level. In second generation labs, it is at both levels.

In fact, IIT Bombay, recognising that some faculty members may be more suited to research than consultancy, is trying to identify loose groupings of faculty members for each area.

Higher level educational institutions like IITs also tend to look out for challenging projects rather than run of the mill ones. One gets, in fact, the impression of a "spearhead", rather than that of a "broad front", which comprises the delivery of tough and challenging jobs to clients. There is less emphasis on facilities - like libraries - or on classes.

They also do not see themselves in competition with other TIs. An IIT Bombay faculty member said his main problem was to REDUCE the demand for his services. Each time he does a consultancy, he said, he doubles his charges, but this has still not deterred the waiting list of prospective clients.

Second generation laboratories try and offer a broad spectrum of services and constantly seek to refine these through market feedback.

They are well aware that they are in competition with other TIs, and take pride in their ability to be self sustaining.

10. Some Explorations : TI Perspective

This section, like the earlier one for industry, deals with perceptions, and the unstated, but from the TIs' point of view.

Our study revealed that many university faculty were reluctant to interact with industry. Some of the reasons for this reluctance stem from following common perceptions about industry.

Sheltered and isolated, Indian industry has been periodically castigated in the media for shoddy workmanship, hence, an unwillingness to associate with it.

There is also often a problem of self perception - one respondent said he was "obviously" not the "industry type".

Another problem, especially with older faculty members, comes from the fact that, traditionally, Indian classroom interaction tends to be one-way - to ask questions beyond a certain threshold is taken as a mark of disrespect.

The same attitude, if carried over to industrial consultancy, can be dysfunctional - give and take would be the very essence of a successful consultancy.

In the case of second generation lab people the situation was different.

In the first place, they would probably have been recruited for their ability for interaction with industry. Second generation laboratories are young and hence unencumbered with many traditional professors. They are, therefore, less likely to have the same problems.

Their major problem stems from the difference in technological levels between industry needs and academic research. All said and done, these people are academics, dependent on published papers and on research to win peer group approval. The more time they spend on industrial problems, the less they have for advancing their own careers. This problem is one that will have to be resolved, but these laboratories have flexible managements, who are aware that they still need to experiment in order to define their organisations' roles.

11. The Future: What are Firms Needs and How will they be satisfied?

Firms' future needs from external sources, as identified by interview respondents, were :

A. Hardware and Software Infrastructure

Needs	Expected providers	Cited by Firm Code
• State of the art software needed to implement flexible manufacturing systems, along with persons who could service the same	International vendors like DEC and HP	Firm 03
• Better publicity regarding the facilities already available for use	Vendors	Firm 16
• Better hardware facilities for storage (disk drives etc)	Manufacturers	Firm 04
• In-house chip design facility. [NOTE, this can, only tangentially be classified under software, included for completeness]	Equipment vendor	Firm 01
• Better availability of quality components. [NOTE : This is mainly a hardware issue, included here for completeness].	Indigenous industry must grow	Firm 01
• More reasonable pricing of imported software, especially that serving as vehicles for domestic products	Government, by reducing duties, and perhaps thro' Govts, TIs, and industry assns sponsoring the local development of alternatives	Firm 06 & Firm 11
• Facilities that are available at Universities should be made available to local industry at reasonable costs	Universities and/or Government	Firm 07

B. Technical Assistance Needs

Needs	Expected providers	Cited by Firm Code
• Assistance with Object Oriented Design	Vendors	Firm 02
• Assistance with Graphical User Interfaces	Vendors	Firm 02
• Access to state of the art algorithms	Possibly NCST	Firm 09
• Data Communications technology	Vendors	Firm 02
• Better access to standards	Unspecified	Firm 01 (standards documentation), Firm 09 (standards testing)
• Easier access to technology	Unspecified	Firm 16
• Better knowledge of new products, processes, and tools	Libraries, databases, consultants	Firm 09 & Firm 11
• Better support of imported software	Vendors	Firm 18

C. Data Communications and Online Database Access

Needs	Expected providers	Cited by Firm Code
• "Phones should work!"	Phone Companies	Firm 07
• Better datacomm services (with reasonable time and cost frames)	Government, vendors	Firms 06, 10 and 12 (suggested the idea of a Data-Comm PCO), Firm 04 (who also wanted support for things like Multimedia and Cellular phones), Firm 09
• More online databases	Public and private parties	Firms 04 and 14 (who emphasised the availability of information on technical tools)
• Online access to databases for export opportunities	Private bodies and/or industry associations	Firms 04 and 10 (who said that online access to global tenders gave competition earlier notice hence more time to prepare bids

D. Financing

Needs	Expected providers	Cited by Firm Code
* More flexible financial regulations so that joint venture partners could be allowed more favourable equity ratios.	Government	Firm 03
* More convenient financing of software development	Banks, Financial Institutions, Government	Firm 02 (who wanted an emphasis on S/W pertaining to NEW technologies), Firm 11 (who wanted easier funding for product development project expenditures), Firm 04 (who cited the lack of hypothecable assets of software companies as a cause of problems), Firm 12 (who wanted the concept of "sweat equity to be recognised), Firm 14 (who wanted some form of instrument to sanction venture capital according to the promoters' reputations without complex procedures).

E. Exports

Needs	Expected providers	Cited by Firm Code
* Marketing and training grants (export related)	Government	Firms 11 and 14
* Simpler and faster way to pick up global application knowhow	Government	Firm 10
* Better knowledge of how Indian products compare competitively with foreign ones	Libraries, databases, consultants	Firm 11
* Image creation for Indian products	Government	Firms 04 and 07
* Funding of overseas market development	Government	Firm 10
* More creativity in the operation of Software Technology Parks	Parks Authorities	Firm 06
* A PERMANENT overseas marketing presence (as opposed to delegations)	Government, interested parties	Firm 10
* Greater freedom to exporters in the expenditure of foreign exchange	Government, through suitable policy changes	Firm 10 and Firm 04 (who expressed it as "freer exchange controls")
* Help in getting visas for export projects	Government	Firm 07

F. Imports

Needs	Expected providers	Cited by Firm Code
* Subsidised access to foreign consultants	Government	Firm 11
* Lower prices and quicker clearances for imported hardware and software	Government, by reducing duties	Firm 12, Firm 11 (who wanted lower duties on h/w and s/w for internal use), Firm 06 (who said that hiring could be an option, which could boost exports. They were also in favour of quicker clearances for low valued consignments), Firm 04 (who said complex products are often imperfectly understood by the lower level functionaries engaged in classification, and the problem is compounded by the fact that intellectual property, such as software, is often described as "goods" in relevant procedure manuals), Firm 09 (who found Customs "helpful" but made the same point about quick clearance of low value imports)

G. Training and Manpower		
Needs	Expected providers	Cited by
• "Live" training in project management skills and in application skills	Companies (possibly public sector ones offering their actual problems to practice on), some suitable changes in college syllabi, Government (by reducing the cost of computerisation)	Firm 07 (who suggest using Cos), Firm 10 (suggested syllabus changes), Firm 06 (who felt that by lowering costs, the resulting spread of computerisation would lead to application diversity)
• Better training in universities	Universities	Firm 08 (who wanted a better industry experience or at least orientation in fresh graduates), Firm 16 (who called for a better grasp of fundamentals), Firm 03 and Firm 09 (both of whom said nothing about quality but were concerned about an adequate QUANTITY of trained manpower)
• Up to date hardware and software at educational institutions	Universities, Government	Firms 06 and 09

H. Others		
Needs	Expected providers	Cited by Firm Code
* Effective anti-piracy measures.	Government	Firm 12
* The freedom to do low volume manufacturing without requiring to acquire the status of a MANUFACTURER, with all its attendant complexities.	Government, through appropriate legislation	Firm 12
* Forums for the interaction of people from TIs and industry.	Initiatives from either side	Firm 08
* A change in the perception of consultancy and other similar intellectual services, which are, currently, not valued much in India	Not specified	Firm 15

12. The Future : What Should TIs Do?

12.1 Education

a) TIs continue to be a first choice for courses for many firms - the reasons including (1) their perceived familiarity with advanced topics, (2) their academic skills, (3) their credentials, and (4) atmosphere. From their side, TIs need to be able to maintain standards in each area, which implies a constant effort to gather several kinds of resources including (A) willing and competent faculty members, (B) appropriate hardware and software - some of which can be expensive, (C) books and journals and (D) high quality "courseware". In the long term, they also need to maintain high academic standards, to the extent possible, comparable with international institutions.

b) The software industry, as compared to users, has a lower volume of needs for more specialised courses, which tend to constantly confront TIs with "chicken and egg" problems. At the same time, it can be said that at any given point in time, a number of software developers will have the same needs, usually pertaining to whatever has lately become current in the field. A way out is for the TI to contact companies on their own, so as to put together the "critical mass"

for a new course. None of the survey respondents have talked of TIs organising inter-firm relations, and it may make sense for them to start now.

c) A special effort has to be made to reach out to the smaller companies - especially the technology innovators. Respondents seemed to regard TIs as part of some remote world!

d) There is little evidence that TIs have taken a proactive role in organising courses, which would imply going out to the firms and convincing them that they NEED a course in some area (as opposed to announcing a course and waiting for participants to come in).

12.2 Consultancy

a) The problem with consultancies seem to be one of structuring. In too many cases, the client asks for the wrong problem to be solved - then later gives the consultant a rating of 2. The consultant, to be successful, needs to be flexible - even to start working on a different problem if need be.

b) A particular requirement of a consultancy which is not always appreciated at the TI end is a need to spend some time getting familiar with the tools used at the client end. A consultant who flatly refuses to use the word processor on the client computer and insists on bringing along his own leviathan may not be very welcome.

c) For both, consultancy, as well as for collaborations, the current level of TI publicity seems grossly inadequate. IIT Bombay and NCST have undoubtedly done useful jobs for industry - but not very many software firms know about them. Publicity material must be designed appropriately so that both small/medium size and the large firms consider them of potential use. The small/medium firms require TIs but faculty are more interested in exotic long term projects which may be offered to them by the larger firms.

d) It would help if TIs could innovate in the area of pricing their services. For example, does anything prevent NCST from turning venture capitalist? Instead of charging for consultancy time, they could ask for royalty payments at a later date, or could convert their fees into high yield debt. The entrepreneur, whose immediate cash flow is thereby eased, will find the TI's services that much more attractive.

12.3 Collaborative Research and Development

The major problems, in the industry's perception as evident from the survey, seem to relate to timeliness and industrial relevance. But there is some evidence that a greater problem is role confusion. In any joint development, there are certain things that each side will be able to do well - and delimiting these will in itself be a big facilitator. Some of the lessons that emerged during interviews were :

a) Choices of methods, system level flows, high level data structures, and the like, are probably better done at the TI end. The go-getting methods of industry are not always amenable to digging the deep conceptual foundations of a product that may need to have a ten year lifetime. However, from its end, the firm should not hand over specifications on June 15th and expect completed flows by June 22nd!

b) Customer interaction must be the firm's preserve, especially as financial and political considerations may be involved. While the TI's persons may sit in on meetings, making

commitments on deliverables must be done by the firm. The same applies to "customer intensive" areas of a project, such as screen layouts.

c) TIs need to realise the existence of price performance tradeoffs, particularly the fact that technical elegance must sometimes be subordinated to development time, or that industry hates "re-inventing the wheel" - this is an area where imitation of others' work is not only allowed, but is also encouraged.

12.4 Forms of Interaction

Consultancy, collaboration, and similar activities are not like buying a loaf of bread - they are essentially HUMAN interactions, and are always more effective when the participants have known each other for a long time.

But it is obviously not feasible for TI personnel to go and sit for long periods of time at user sites just to build up relations - formal and semiformal mechanisms must be provided from both sides to ensure regular contact. Possibilities are :

a) Periodic review meetings for developmental projects.

b) Development of key pieces of technology which are sufficiently "stand alone" to be done by an outsider.

c) Some of the ongoing training - virtually all respondents had some form of in-house training - could be handled by TI people.

13. Implications for Government Policy

13.1 In section 3.3. we have described in some detail the role of the government in the development of the software industry. As pointed out in that section the government's emphasis on the software industry is of relatively recent origin. In a sense the government's computer policy of 1986 marked a watershed in the industry's evolution. Since then a number of steps have been taken by the government aimed at the development of the industry; however, as discussed previously senior executives in the research firms felt that they had had negligible impact on the industry. Obviously there seems to be a communication gap between industry and the government. This study has not investigated this issue in detail and hence the government would do well to consider conducting a systematic study of how a better understanding with industry can be brought about to exploit its potential.

13.2 Fiscal and export incentives have had the greatest impact on the industry. However, there seems to be some contradiction between the findings of the interview and mail surveys regarding the remaining government policies (Table 5.21).

Interviewed firms, which used grants, special technology loans and standards/testing related policies have rated them to be fairly useful with a mean impact rating of around 3.5. On the other hand very few of the mail surveyed firms rated these policies as above average. For effective policy design the effectiveness of existing government policies needs to be analysed on a systematic basis.

13.3 In previous sections we have explored the reasons for usage and non-usage of TIs. An analysis of these indicate some areas in which the government may be able to play a role to assist in the development of the industry.

* The government may encourage collaborative research between firms and universities through different kinds of incentives directed towards "frontier technologies" as the survey pointed out the presence of a "frontier technology" component in the business as a reason for using TIs.

* The government may consider providing specific "project" funds to TIs to develop their capabilities in state of the art techniques such as SSAD.

* Acquisition of specialised facilities by TIs may be supported by the government to enable firms share them as many firms may not find it economical to acquire them or may not have the reasons to acquire them. Examples from Section 11 are (a) publicly owned chip-design facility; (b) quality control equipment to ensure the quality of components; (c) state of the art algorithms; (d) libraries, and databases, etc.

13.4 Respondents indicated a need for better data communication services, easier access to technology, better access to standards, etc. In all these the government may play a promotional role by encouraging private sector firms and entrepreneurs to step in where there is need or by providing information about availability of technology and assistance to firms in evaluating technology. In strategic areas the government, if in its judgement it is desirable, may even assist in negotiating with the technology vendors. "Better access to standards" is an area critical to the whole industry and hence the government may consider increasing investments in this area.

13.5 Respondents from interviewed firms mentioned a few other issues on which the government should play an active role; (a) software piracy, (b) virus protection, (c) simplification of definitions for ease of interpretation of the Income-Tax Act as applicable to the software industry, (d) software quality certification standards, and (e) development and implementation of measures for certification of software personnel.

13.6 Currently there is only one TI (NCST) specifically designed to meet the needs of the software industry. However, with the industry growing at a rapid pace it will soon be difficult for NCST to cope with the demand for technical services. We feel that the government should take proactive steps to promote additional TIs in different regions where there are clusters of software firms or where cluster formation is to be encouraged. In this process the active cooperation of the industry would be beneficial in designing the TIs' strategies and organisational mechanisms geared towards the industry's needs right in the beginning.

13.7 The area of "financing" needs to be given significance by the government. The government alongwith developmental financial institutions need to design innovative financial schemes for supporting software development. Some specific needs mentioned by respondents were; (a) financial schemes geared towards new technologies; (b) easier funding of product development; (c) special schemes for financial support of software companies as they lack hypothecable assets, etc.

Appendix A: Acronyms and Short Names

CCS	:	Cash Compensatory Allowance. A government export promotion scheme.
CDAC	:	Centre for Development of Advanced Computing.
CDOT	:	Centre for Development of Telematics.
DEC	:	Digital Equipment Corporation.
DOE	:	Department of Electronics, a government department concerned with many aspects of the computer industry.
ECIL	:	Electronics Corporation of India, a government undertaking which made India's first indigenously manufactured computers in the '70s.
EDP	:	Electronic Data Processing, here used to refer to the computer services department of an organization.
HP	:	Hewlett Packard, an international firm prominent in electronics and computers.
IBM	:	International Business Machines, the worldwide computer industry leader.
ICL	:	International Computers Limited, the British flagship company in the international computer industry.
IISc	:	Indian Institute of Science, a TI.
IIT	:	Indian Institute of Technology, a TI.
ISO	:	International Standards Organisation, in this report mentioned in the context of the ISO 9000 series of quality related standards.
MIS	:	Management Information Systems, used in this report in the same way as EDP.
NASSCOM	:	National Association of Software Companies, the software industry's industry association.
NCST	:	National Centre for Software Techniques. A TI, the only one concerned exclusively with software.
PCO	:	Public Call Office (a phone call box), A respondent suggested the idea of a datacom PCO.
SSAD	:	Structured Systems Analysis and Design, a technique wide use in software development, and the subject of courses taken by more than one respondent.

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