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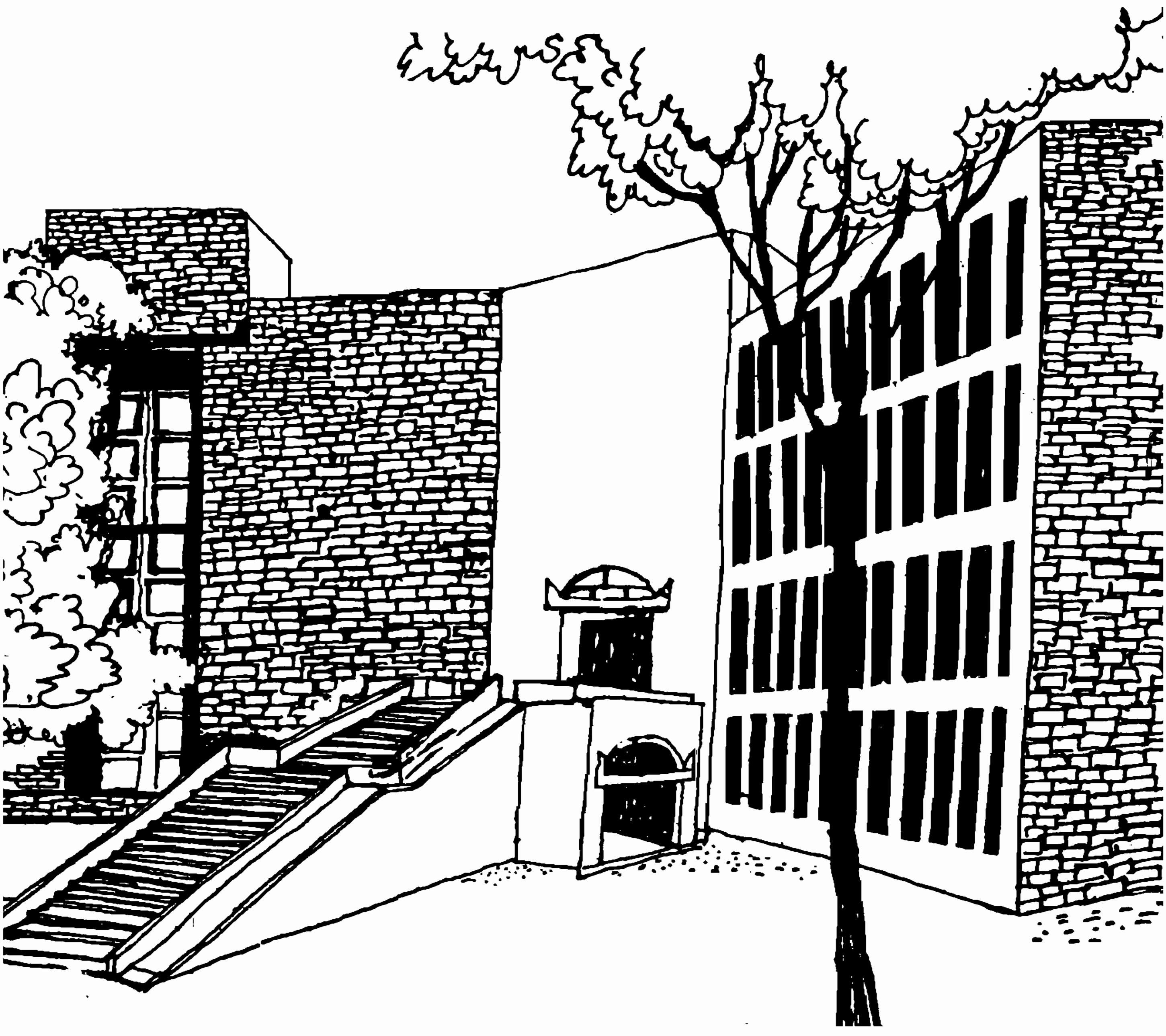

Interaction Between Firms and Technology Instituions in India: Reflections on a Multi-Industry Study

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Interaction Between Firms and Technology Institutions in India: Reflections on a Multi-Industry Study

Considerable importance has been given by the government of India to the creation and nurturance of a strong and autonomous scientific and technological base.' Towards this end, the government set up the Ministry of Scientific Research and Cultural Affairs in 1948, Council of Scientific and Industrial Research (CSIR) and the Atomic Energy Commission during the period 1948-54, Defence Research and Development Organization in 1958, Department of Science and Technology (DST), Electronics Commission and the Department of Electronics in 1971; the Biotechnology Board and Department of Biotechnology in the 80's.

Notwithstanding the significance of the investments made on scientific and technological development, it has been widely perceived that the level of utilization of research conducted at the national research laboratories has not been satisfactory.

Following reasons could be attributed to the ineffective interaction between research institutions and industry:

(a) lack of market information at the time of selection of research projects;
(b little possibility of economic return from the technologies developed;
(c) preference of Indian firms for foreign technology;
(d) inadequate coordination between different sectors of society resulting in the failure to develop its potential for technological innovation; and
(e) lack of technical and financial resources and unsuitability of the know-how for production.

A few very successful cases of technology transfer from National laboratories to industry have also been documented. (Chaudhuri, 1986).

With the balance of payments and fiscal crisis in the late 80's and the announcement of the New Economic Policy in mid-1991, the inadequacy of linkage between industrial organizations and research institutions has been felt at several quarters.

A number of factors determine the quality of interaction between industrial firms and technology 2supporting institutions (TI). The propensity of industrial organizations to seek support from TIs is likely to be determined, for example, by the government policy towards industry, regarding industrial licensing, foreign collaboration and investment, fiscal policy, trade policy; its policy for infrastructure development, nature of industry - whether it is dynamic or stagnant, nature of competition both domestic and international; company's cultural characteristics, development of related and supporting industries and level of technological sophistication of the country.

There are a number of characteristics of industrial firms that can be hypothesised to have a bearing 2on their desire to seek help from TIs. They are

(a) Mission and strategic objectives
(b) Competitive strategies adopted - cost leadership, differentiation or focus
(c) Technology strategy pursued by the firm
(d) Type of organization - independent, embedded or subsidiary of larger firm or a multinational company.
(e) Organizational culture
(f) Top management's background and values
(g) Nature of the product and embedded technology

The nature of the TI itself is also expected to have an influence on their interaction with industrial people and skills available, funding structure, kind of facility available in the TI, etc. may be expected to play an important role in TI-Firm interaction.

It is in this context that we undertook a study of the linkage between the industry and technical institutions. In this paper we present the findings of a mail survey carried to study the usage of technical services offered by the technical institutions. We received responses from 132 companies belonging to various sectors and size categories. Initially the mail survey questionnaires were sent to about 100 firms whose names had been mentioned in a variety of sources; directories of firms in different industries, lists of companies available from various institutions, lists of firms from newspapers, financial dailies, etc. After a gap of about one month we remailed questionnaires to those who had not responded. After about another month we remailed questionnaires to those who had not responded and also to another 500 additional firms. The objective was to obtain about 35 responses in each of the industrial sectors. However, as evident from the table we were able to obtain the desired response only from the auto parts sector. The response from the textiles, software, and pharmaceutical sectors have been reasonably good. However, the response from the foundry, polymers and machine tool sectors was far from satisfactory.In addition we can also mention that we received good response from the companies in the west and southern zones. Table 1 provides the distribution of the respondents across various geographical zones.

1. Objectives of the Study

The objectives of this study were to understand how and under what conditions industrial firms and technology supporting institutions interact. An understanding of the patterns of interaction between TIs and firms would enable us to identify factors which contribute to successful technological support to industrial organizations. We wished to identify the characteristics and circumstances of a TI-support structure for firms, individual TIs and the method of firm-TI interaction which led to or provided good support to firms for technology improvement.

A by-product of this study was the identification of technology related government policies that significantly influenced industrial technological development.

We tried to understand the probability, frequency, nature, and importance of firm level interaction with TIs as a function of:

(a) Nature/character of the TI itself,
(b) the industrial sector to which the firm belongs, characterized by level of technological maturity, industry structure, and government policies applicable to the industry; and
(c) nature and character of the industrial firm.

The industrial sectors covered in this study were Auto Components, Foundry, Machine Tools, Pharmaceuticals, Polymers, Software and Textiles. These sectors differed from each other on a number of dimensions.

(a) Total industry turnover
(b) Dynamism - growing or stagnating
(c) Government's policy
(d) Technology infrastructure
(e) Educational institutions catering to industry's needs
(f) Structure of the industry and nature of competition
(g) Nature of the technologies utilized
(h) Level of development of related and supporting industries.

Of the seven sectors foundry and textiles were the oldest. Machine tools, auto parts, pharmaceuticals and the polymer sectors were also fairly old though of late the auto parts and pharmaceuticals sectors had shown considerable dynamism. Software was of relatively recent vintage, though. the had been in existence for long enough period to have developed a good repertoire of technological capabilities.

Based on the findings of the study, certain implications were drawn industrial firms, TIs and policy makers.

In this paper we attempt to synthesize the findings of the study and present some thoughts for firms, TIs and industry.

2. Technological Capabilities of Firms and Demand for Technical Services

To analyse the enterprise level capabilities in the seven sectors we used some aspects of a framework developed by Sanjaya Lall (1987) and a conceptual scheme of organizational stages in technological development developed by Chaudhuri (1980, 1986). Lall described five constituent elements of technological capability: pre-investment choice, project execution, plant operation, technological improvement and technology transfer. Chaudhuri described an organizational stage model of technological development of firms. The model, based on studies of technology acquisition from foreign collaborators/licensors and its subsequent assimilation into the organization posits that technological evolution of firms could be conceptualized in the form of four sequential stages (Box 1)

There was some degree of overlap between our framework and Lall's scheme though the emphasis was different. The latter focused on the technical content of the activities whereas the former on the organizational issues related to acquisition and assimilation of technology.

Within the sectors there were inter-firm variations in technological capabilities. The medium sized and large firms in most of the sectors had developed fairly good project preparation and execution capabilities. Machinery suppliers do, however, provided services for installation and training as required while supplying new machinery. Skills related to project identification, feasibility studies, product range specification, specification of input requirement, deciding on plant scale, technology, negotiation with collaborators when required for acquiring new technical know-how, negotiation with consultants, building contractors, equipment search, procurement, vendor development, plant commissioning, training were fairly well developed. However, even, medium sized and large firms occasionally involved consultants when plant expansion was very large and technologically complex. Quite often depending on the sector, basic process design and detailed engineering work was contracted out to indigenous engineering consultants.

The same cannot , however, be said of the small scale industry in the various sectors though the products manufactured by them were technologically simpler. As a result small firms quite often took the help of friends, and consultants in the industry in identifying technology, selecting machinery and product and even part time help of engineers and technicians who worked full time in large organizations,

Some large firms had highly developed project preparation and execution capabilities as evident from the example of a textile firm which was one of the leaders domestically and was aiming to become a leading company worldwide in denim manufacture. This company not only decided to choose an unusual route for the manufacture of denim but also provided technical ideas to a Japanese machinery supplier to modify the design of its existing machinery to suit its requirements. In its quest for further modernization and capacity expansion it decided to obtain foreign exchange loans from the International Finance Corporation. It made a successful presentation to the international financial institution and is currently in the process of augmenting its capacity and improving technology further.

Box 1

Stages in Technological Development at Firm Level

Stage 1: **Acquisition of Technology**: Key Managerial Tasks: Recognizing the need for seeking technical collaboration; Search for possible collaboration alternatives; Negotiation on: Products to be manufactured, Mode of collaboration and terms and conditions, Make/but decisions, Plant location, Financial scheme, etc. Deciding on technical consultant, Final choice of collaborator.

Stage 2: **Technology Adaptation**: Key Managerial Tasks: Creating the project team for implementing the project, Formulating strategy for developing technical skills at different levels: deciding on whom to send to collaborator's plant; and in what areas, Detailed study of manufacturing system at collaborator's plant, Selection of Manufacturing technology consistent with local capabilities of machinery and component suppliers ascertained after detailed survey; Negotiate with potential suppliers, collaborator, building contractor(s), technical consultants, etc.

Stage 3: **Technology Utilization**: Key Managerial Tasks: Commissioning the plant and establishing production, Creating specialized organizational sub-units for handling new tasks such as: production planning and scheduling, inspection and quality control, industrial engineering, personnel and industrial relations, purchase and materials management, sales and distribution; setting up and institutionalizing various management systems like: production planning and control system, quality control system, inventory management system, etc.; Inducing managerial staff in key positions, Establish systems for coordination of the work performed by the various departments; Development of policies in interrelated functional areas; Setting norms for production, quality maintenance, etc.

Stage 4: **Technology Improvement and Development**: Key Managerial Tasks: Creating organizational sub-units for performing the following: Systematic analysis of feedback on product performance, Quality assurance, Value engineering, Cost and productivity improvements, New product development, Research and development activities leaning more towards the 'R' end of the R&D spectrum; systematic environmental analysis for ascertaining demand for new products, Locating and negotiating with potential technology suppliers for new products if technology is not available internally, Developing coordinating mechanisms for integrating the work of the new departments and existing ones; Developing company-wide planning and budgeting systems and more sophisticated information and control systems.

For a fuller discussion see Shekhar Chaudhuri, "Managing International Technology Transfer: A Corporate and Control Environment Perspective", in P.N. Khandwalla (ed), *Social Development: A New Role for the Organizational Sciences*, (New Delhi: Sage Publications), 1988.

The machinery manufactured by Indian companies was generally quite far behind developed country standards, hence, the productivity levels attainable by the use of Indian made machines was generally lower. However, these machines had been found to be appropriate by a large majority of firms. Firms aiming to become important players in the international market, however, preferred to procure machinery from foreign suppliers, which had high speeds, and were less energy using more automated and therefore less labour using. Machinery suppliers for the higher end of the market were therefore not very well developed in India. This was true of most of the sectors covered in this study.

Indian firms in the manufacturing sectors had achieved a fairly high degree of process engineering capabilities and have progressed well through the two stages.

One foundry group set up a new unit to manufacture high quality investment castings. The new unit made all the necessary investments and recruited qualified professionals. From a loss making situation initially it has made a turn around and is now planning to move into use sophisticated areas.

This was more true of large sized firms which had specialized organizational departments charged with this responsibility. In the engineering companies process planning manufacturing planning, plant engineering, maintenance departments, welding engineering, etc. all catered to this task. One company bought over a closed textile unit and transformed it into a major contender in the Indian textile industry. Though it purchased the latest machinery it made most process changes through in-house efforts. In many cases the objective of process changes has been to reduce costs. The Indian denim giant pioneered an indigenous process of producing denim though finally the company did not use it for mass production as the engineers found that imported technology could be more cost effective at large volumes. However, the capability that the company's R&D had developed played a significant role during the negotiation with the collaborator and also with the machinery supplier.

One pharmaceutical company which is today the largest manufacturer of IV fluids is very clear about pursuing competitive strategies to attain cost leadership. To achieve a low cost position it decided to go for large volume manufacture through the use of highly productive imported machinery while focusing on all possible cost cutting strategies like reducing raw material usage through optimization of material cutting techniques, material changes, layout changes, good machinery maintenance, etc. Other examples of how firms managed technological change help reinforce this point.

We would found only few organizations among the middle sized and large ones in each industry which had made partial progress in reaching stage 4. The textile firm with global ambitions certainly has acquired some of the characteristics of a stage 4 organization. A pharmaceutical company, set up in 1907 by three persons and credited with having been the first in the private sector to produce penicillin may be considered to be a partial stage 4 organization. One of the multinational subsidiaries in the pharmaceutical industry has an R&D set up which is part of the parent company's global R&D system. Only a few aspects of the whole chain of activities starting from search for new plant molecules to their conversion into a commercial drug are carried out in India. The results of studies done in India are then fed into other research centres of the parent company.

Limited number of larger organizations in our sample might qualify to be in stage 4. Though large they did not have the resources and risk taking capability to launch themselves into full scale new product development. Interviews with senior executives in the pharmaceuticals industry revealed that development of a new drug might require on an average Rs.200 crores which is under more than the annual turnover of most of the companies in India. Though most medium sized and large firms had absorbed the originally imported technology, adapted it to suit local conditions and also improved upon it to meet customers' requirements they still lack the capability to engineer completely new products on their own.

In our discussion so far we have left out the software sector because of its uniqueness. One way to segment the industry in India is to consider their nature of work. "Export houses" undertook a significant amount of software development for a single foreign partner who may use those products and services or may sell them in turn. These firms got their technologies from their foreign partners. "Body shoppers" were also export houses with an emphasis on providing contract labour, rather than pushing their own products or skills. Another variation of the export oriented firms mentioned above was firms engaged in overseas contracts for products and services. These also sourced their technology mostly from overseas sources but also used local TIs for large amounts of training. "Agency businesses" sold imported software products. The organizations took responsibility for installation, customization, and provided subsequent support. In an agency operation the importing agency got its people trained by the foreign software supplier. Next came the organizations that depended on their in-house capabilities to a great extent. "Niche players" used their expertise to build custom software for clients. The application know-how came from users. In our sample there were some examples of product innovators who had developed a new product or a major variation of an existing product. In their efforts to develop these products the firms had felt a need for external technical assistance but had not used existing TIs as they were uncertain of their abilities. One large organization had used consultants. "Package experts" sold expertise on a particular software. Their role was similar to that of agency houses. The difference was that the package was not imported by them.

In the software industry manpower was found to br the most critical resource and was the biggest cost item and management of the development process was the equivalent of production planning and control in plants in other industries. Most respondents in the software industry felt the need to adopt structured development methodologies (SSAD being the most common) and to get ISO 9000 certification.

Given this background of technological capabilities of the seven sectors it is not difficult to understand the pattern of interaction between firms and the TIs that has emerged from the surveys. Both the firm level interviews and the mail survey of firms clearly showed that the demand for technological services were in the broad area of "Process Engineering". Specifically standards and testing, education and training, information, problem solving and troubleshooting and consultation through technical networks were the most used services.

"Product Engineering and Process Innovation" were lower on the priority list of service requirement. For collaborative R&D foreign investors ranked first in the mail survey. This is supported by our understanding of the evolution of Indian industry. For introducing new products or major product changes firms have generally depended on foreign licensors. The government's policies until recently have encouraged import substitution which spurred firms to put in tremendous efforts to adapt the foreign technology, indigenous components, stretch the capacity of existing plants, build capital goods in many cases to reduce import cost. In industries like foundries, and textiles the firms' engineers have made heroic efforts to continue to use obsolete plant and equipment. During our discussions in the field we came across even large firms using derelict machinery and the plants' upkeep in great need of major overhauling. We were amazed to see the poor infrastructure of a region which boasted of being one of the major exporters of ready made garments.

In terms of the sources of technical services the pattern was quite clear. In-house laboratories or facilities ranked first followed by long term suppliers, industry associations, long term customers and consulting firms. National technical institutions did not on the whole, come on the preferred list though for education and training they were quite important. Universities, research associations and academic associations were the least preferred. Some of the common problems associated with these institutions were lack of technical capability, timeliness, high fees and confidentiality. National technological institutions were considered to have a problem regarding timeliness. In a broad sense all these perceptions were symptoms of a lack of orientation to industry's needs.

We attempted to determine whether there were any sectoral differences in terms of use of services and technology sources. Regarding use of services we did not find very strong indications of differences across sectors. It seemed that the foundry and polymers sectors did not give as much importance to collaborative R&D and standards and testing. A caveat must, however, be mentioned. These findings must be seen in the light of the fact that there were ten or less respondents in the mail survey for these sectors.

Interestingly the foundry sector gave more importance than the others to long term customers, foreign investors and licensors and academic associations.

3. Capabilities of TIs and the Supply of Technical Services

The supply structure of technical services has been influenced by government's science and technology related policies.

Our survey of TIs showed a preponderance of government owned TIs confirming the well known fact that most initiatives for developing the S&T infrastructure in the country had been taken directly by government or government owned institutions or organizations. TIs have concentrated on acquiring sophisticated measurement equipments, standards and testing facilities, library/information and data bases and experimental laboratories.

If this is seen in the light of own finding that a good correspondence existed between what firms used and what strengths TIs had attempted to build. Very little effort had gone into building other sophisticated and capital intensive facilities like pilot plant facilities and computer aided design facilities. However, in the context of the governments' thrust towards globalization of the economy services in these areas may become much more demanded by industry. Unless the TIs acquire more advanced facilities they may become redundant. In fact during our discussions with the new technologically dynamic firms the point was oft-repeated. Even "training centres" have not received much importance in their capital allocation programmes.

It is heartening to note that in the view of the TIs their major accomplishments during the last 10 years were in the areas of new product development, new process development, development of human resources and establishment of sophisticated facilities. Contrary to popular belief publications in reputed national and international journals do not seem to be the most important objectives. These findings are, however, disconcerting. On the one hand industry seems to use one kind of services for which TIs currently have with facilities; on the other what TIs consider as their important achievements are very different. One conjecture is that TIs have attempted to develop new products and processes on their own driven by what they perceived as potentially useful to industry. To the extent that work on new product development and new process development help build capabilities of scientists and technologists in general one can say that these investments have not been wasteful; however, in a capital scarce country like India, more so at a time when the national R&D budget is declining it is a moot question whether such activities lead to development of useful capabilities. The question therefore is how can TIs create an impedance match between themselves and industry's current and future needs ? The answer perhaps needs to be found, in an examination of the model of technology development and transfer that underlies the modus operandi of Indian TIs. This point we shall take up for further discussion in the next section.

An interesting feature of the strategies adopted by TIs was the use of outside technical experts or through networking with other institutions. This strategy is a noteworthy development as it helps TI augment their capabilities while providing flexibility.

Our data showed that TIs served mostly the very small (employees < 50) and large (> 500 employees) firms. Firms in the categories in between did not seem to be given much importance. This data, however, went counter to our field survey findings. During our discussions with the many small firms, we were given to understand that they felt the need for technical assistance from the TIs but they thought the TIs would not be interested in solving the problems of small scale industry as their problems would not be complex or interesting enough for the scientists and engineers working in the TIs. This divergence of perceptions of the demand and the supply sides of S&D services is due to probably to the sampling procedure. In most of the sectors covered by us there was a large number of small firms. Our sampling procedure deliberately ensured that we did not ask the TIs to suggest firms for indepth discussions. Had we done that we would perhaps had a different picture altogether. We probably landed up with those small and medium firms for interviewing which had not had any interaction with TIs. Our data reflects the governments's encouragement of small scale industry in general during the last two decades or so. As we have seen in Paper 5 many TIs were set up by the government with the specific purpose of providing technical support to small scale industry. Quite a few of the TIs in our sample had set up extension centres or outreach departments to go closer to clients not served appropriately by the head office. The TIs seem to be giving appropriate attention to intellectual property rights (score of 4.4/5) but it is not clear why the score one "confidentiality" was low at 3.7.

4. Implications Institutional Priorities

What do we learn from this study ? Are there some implications that can be drawn from the perspective of policy makers and the technological institutions ?

Textile research associations have been very successful in interacting with their members. In fact very recently when one of them raised the membership fee there was a sudden drop in membership. But that was only temporary. Some of them even have a few foreign members from South East Asian countries. The key to their success has been their focus on "process engineering" type of services with the aim of getting the maximum mileage from existing investments, through studies of inter-firm productivity standards and bench-marking, development of maintenance norms, quality control techniques, raw material waste reduction efficiency improvement techniques, etc. Their work seems to have been driven more by industry needs than scientists' and technologists' predilections. The TRAs' success in being closer to industry seem to be due to the fact that they have been promoted by industry with government support. Their boards of directors are strongly influenced by member firms' representatives. Hence their research and technological agenda reflects to a considerable degree the needs of industry. However, we also have contrary experiences. The experience of the cooperative research association for the auto industry could have been much better. The reason why auto parts manufacturers have not had strong interaction with the research association has also much to do with the structure of the industry, nature of technology and dynamism of the industry. For a long period of time the auto parts industry was hamstrung by government regulations. The growth in the automotive industry was slow because of licensing restrictions. The gradual liberalization since the beginning of the 80s alongwith the advent of Maruti Udyog in collaboration with Suzuki of Japan provided much needed technological ripples in the otherwise placid waters of the auto parts industry. But the big push came in mid 1991 with the dramatic liberalization of the Indian economy. During the slow growth period under regulation technology did not play a major role in competitive success but today the situation is different. Technology now is a critical success factor but that is being supplied by foreign licensors. The role of the research association may be directed towards technology gap filling which may be expensive to service through further collaborations or licensing.

The CSIR laboratories have for long operated under a technology push paradigm - scientists in the laboratories determine from their own understanding based on interactions with colleagues and through reading of journals a research agenda, which they think would be relevant to industry. They then develop technologies for tackling the problems identified by them and then offer the solutions to industry through the NRDC, the agency created to sell the technologies. Technologies developed under this paradigm have limited probability of success because of a variety of reasons; lack of a real market for them, technological uncertainty in scaling up, difficulty in mobilizing venture capital, communication problems between scientists of CSIR laboratories and the potential clients' engineers, etc. On the other hand there are a number of successes as well. Most of these successes have been in areas requiring expertise in chemistry and chemical technology and those which are small scale technologies which do not require large engineering inputs for upscaling. Engineering is an area of weakness of CSIR laboratories which some of them are trying to overcome either by building engineering design teams or by networking with engineering consultants.

An example of a basic research institutions, IPR specializing was plasma physics is worth looking at in this context. They used a novel method to develop a framework for collaborative work with industrial clients. First they brought out a newsletter which they sent out to potential industrial clients. On the basis of some interest that got generated they organized workshops in different cities which were attended by potential industrial clients. On the basis of this interaction they evolved a framework:

1. Potential user conducts market surveys, estimates financial investments and other input requirements, competitiveness of plasma technology with existing processes, etc. IPR on request helps in information gathering of technical aspects.

2. After identification of a specific product or process IPR helps in developing the basic process know-how using its own laboratory facility but with the help of manpower provided by the client.

3. IPR helps in the next phase - prototype development - i.e. development of a shopfloor compatible system. For this phase the client could take help from technology promotion agencies like ICICI and NRDC in the form of venture capital. IPR provides the technical support for detailed engineering design, fabrication supervision, and final commissioning of the system.

In a short period of time IPR has been able to initiate a few collaborative ventures. This approach needs to be examined more closely as there seems to be considerable merit in it as it builds in collaboration between the TI and the client right from the beginning.

Some of the more successful educational institutions had set up separate departments responsible for coordinating their consultancy activities industry associateship schemes. These institutions have brought out very useful hand books providing potential clients with readily available information about institutional expertise and achievements with the help of charts, graphs and photographs. Even CSIR has brought out user friendly directories which reflect their changing orientation.

The experience of a private research institution is telling. SRII, created as an institution to cater to the needs of industry became divorced from industry as a result of taking up basic research projects sponsored by a funding agency. When the funds dried up it was in dire straits as it found it difficult to reconfigure itself to take up industry related work. Over the last fifteen years it has once again restructured itself to cater to industry needs. Most of its 2000 odd industrial clients are small firms who buy small technology packages.

Some major implications that may be drawn from the study are:

(a) A paradigm shift from technology push to collaborative technology development and transfer may improve the effectiveness of the national technological institutions.

(b) It may be useful for TIs to focus initially on process engineering type services rather than major new product and process innovation projects. This is what the market seems to demand. Gradually with better understanding between TIs and industry there can be a move into more sophisticated areas. This of course would depend on whether the competitive forces which have been set in motion remain and also whether the TIs are able to acquire more sophisticated technological capabilities.

(c) TIs may consider creating an "inside user perspective". This will put to test their ideas even before the real user comes face to face. Some institutions have already started moving in this direction by creating marketing departments.

(d) Networking between TIs and between TIs and consultants may be an effective alternative to vertical integration in TIs to cater to industry's needs.

(e) Needs assessment studied and problem centred industry-TI conferences may be useful means of interaction. In fact a strategy of working with multiple methods may have high pay off.

(f) Extension centres may be used by those TIs who currently do not work with small scale industry. Many TIs successful in catering to the needs of small scale industries have used this organizational mechanism.

(g) Lastly TIs may consider instituting strategic planning in their organizations to chart out their future directions.

On the whole India has an enviable S&T infrastructure by developing country standards. For about three decades the government concentrated on building the infrastructure with only occasional exhortations to scientists to perform societally relevant research. Initially the industrial infrastructure was weak, so the S&T infrastructure and industry grew divorced from each other notwithstanding the organizational linkages between economic planning and S&T planning which turned out to be temporary and periodic in nature. With a reevaluation of the economic strategy in the early 80s a degree of liberalization was brought about which was strengthened in the latter half of the decade. This period also saw increasingly strident demands for India's S&T infrastructure to perform industrially relevant research. In the post NEP of mid 1991 the changes have been dramatic.

The scientific and technological institutions are going through a period of intense introspection. For many the challenge of raising at least a third of their revenues from client sponsored projects is a tall order. They would have to undergo traumatic reconfiguration. But for others it is an opportunity. Some dynamic institutions have already instituted strategic planning exercises to chart out their future directions. A few are trying to team up with foreign firms from advanced countries leveraging their high skill to manpower cost ratios. Incentive schemes for scientists to motivate them to work on industrial projects are being developed by some laboratories. Partial industry ownership of research institutions is another option to change their orientation and new private sector initiatives are in the offing in the auto parts and pharmaceuticals sectors. Some of India's research institutions look at the horizon with great hopes and are revving up to take off. These may be small in number but are likely to set off a chain reaction.

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