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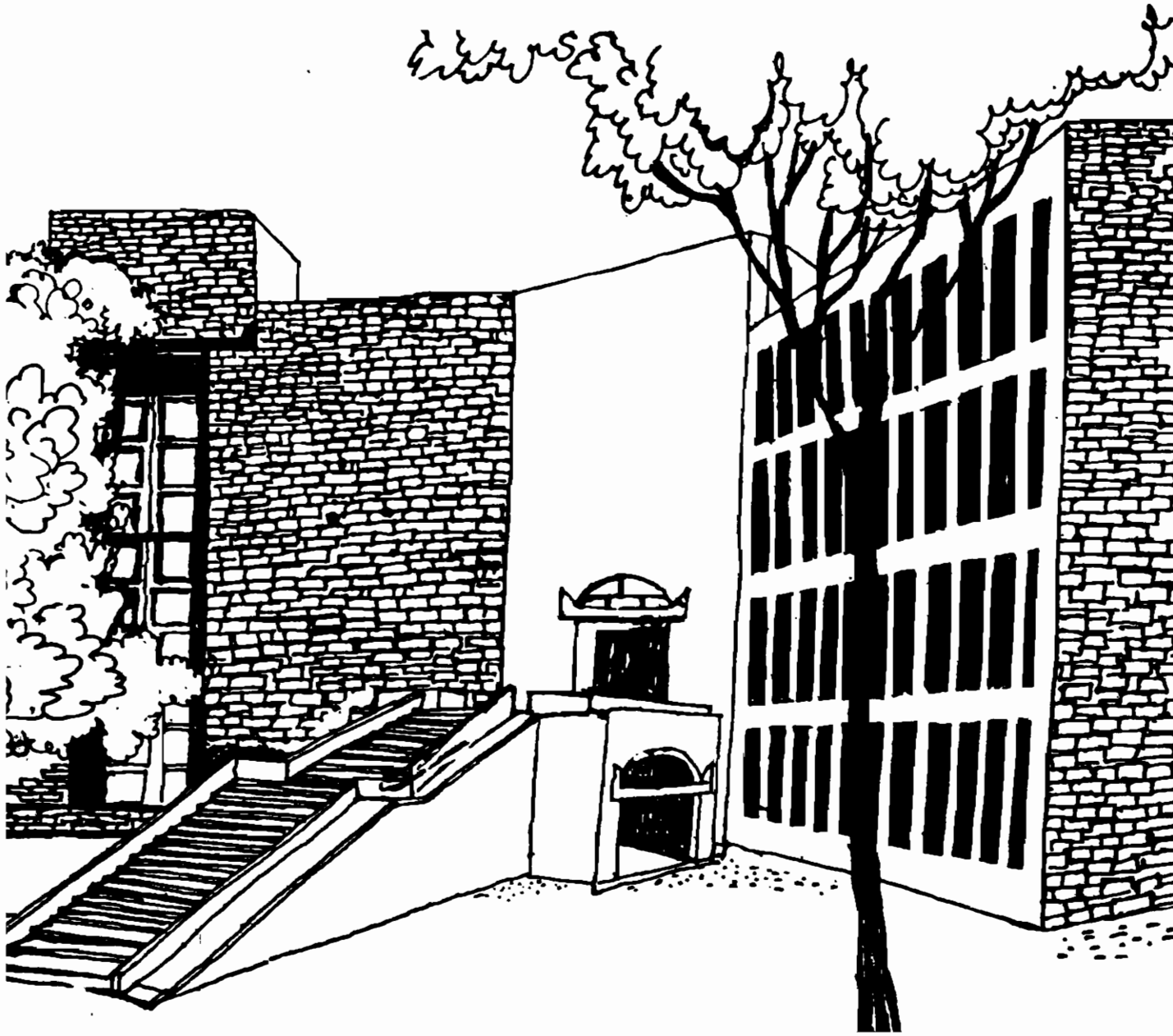

# INDUSTRY-TI PARTNERSHIP IN INDIA
# SELECT TI CASE STUDIES AND IMPLICATIONS

By

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# Industry-TI Partnership in India

## Select TI Case Studies and Implications

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# Industry-TI Partnership In India

## Select TI Case Studies and Implications

### Introduction

In recent years there has been an increasing concern regarding the effectiveness and efficiency of technology institutions. At an international seminar in early 1995 the Acting President of WAITRO in his welcome address said:

> ... All over the world, in developed as well as developing countries and in transition economies, we are seeing a challenge to industrial research and development institutes... Our economies are evolving into truly knowledge-based economies where the competitiveness of any economy hinges on its ability to make R&D at an international level available for the last company in the industrial structure of the country... Institutes in many countries used to have a considerably easy existence based on fairly abundant availability of good and non-competitive sources of funding. However, now in all communities availability of funding is diminishing and we are thus expected to prove our efficiency and our ability to deliver in the market place (Qureshi, p. vii).

Several developing countries have launched programmes to restructure their technology institutions to respond to the changing needs of industries which are undergoing a process of liberalization and globalization. Sri Lanka (Jayatissa, 1996) and Malaysia (Nesadurai, 1990) among others have initiated programmes for restructuring technology institutions. In India subsequent to the initiation of the New Economic Policy in mid 1991 the CSIR launched a new strategy aimed at (a) reorienting R&D programmes towards the needs of industry, (b) forging alliances with various links in the innovation chain, and (c) effective management and marketing of its knowledge base (Joshi, 1996).

This paper briefly presents the findings of a study of industrial technology development in India undertaken during the period 1993-95 (i.e. shortly after the launch of the New Economic Policy) and then discusses case studies of the experiences of several technology institutions some of which were in the process of transforming themselves during the study period. The others had already undergone restructuring programmes prior to the new policy. The technology institutions whose experiences are discussed in this paper are: Institute for Plasma Research (IPR), National Chemical Laboratory (NCL), Shriram Institute for Industrial Research (SRII), Centre for Development of Advanced Computing (C-DAC), National Centre for Software Techniques (NCST) and Ahmedabad Textile Industry's Research Institute (ATIRA).

**Survey Findings**

Indian manufacturing firms use a variety of organizations as sources of technical know-how and services amongst which technology institutions form an important group. Technology institutions (TIs) as defined in this paper, may be either profit making or not-for-profit organizations that provide technological support to industrial firms. They may be of various types; (a) educational and training institutions; (b) research organizations that include autonomous organizations, special departments and institutions directly under government ministries, private research organizations and cooperative research organizations; (c) industry specific research and training institutions; (d) technical institutions for small industry; (e) technical consultancy organizations, information centres, (f) standardization agencies and industry associations (Chaudhuri and Dixit, May 1994).

A mail survey of 132 manufacturing firms (randomly sampled) belonging to seven industrial sectors[1] done as part of a larger study of technology development in India (Chaudhuri and Dixit, 1994) revealed that 45 per cent of the respondents had used national technological institutions as a source of technical services; 40 per cent had used local and regional technical institutions; 38 per cent had used universities; 36 per cent had used research associations and 19

[1] The industrial sectors included auto parts, foundry, machine tools, pharmaceuticals, polymers, textiles and software.

per cent had used academic associations. These figures of TI usage by industrial firms in India are significant considering that the TI usage rate ranged from approximately 32 per cent for small firms to around 75 per cent for large firms belonging largely to the same industries across 8 countries that included economically advanced as well as developing ones (World Bank, 1995).

What was also interesting to note was the respondents' reported usage of foreign collaborators as a source of technical know-how and services. Only 33 per cent of the mail surveyed firms had used foreign investors as sources of technical services. This information apparently contradicts the popular perception of the dominance of foreign firms as sources of technical know-how in Indian industry. The study covered a cross-section of seven industries spanning several firm-size categories, which perhaps explains the apparently contradictory finding.

I must hasten to add, however, that the same respondents ranked foreign investors as "number 2" amongst the 12 sources of technical services in terms of their importance as a source of technical services. What one may surmise from this is that though a relatively small percentage of firms had used foreign investors, those that used them found them to be very useful. Incidentally firms' own R&D departments and laboratories were ranked at the top as sources of technical services on both counts, which is understandable given the tacit nature of much technical knowledge and the control that a firm can exert on the development and deployment of its technological resources.

As evident from the above, on an aggregate basis the usage rate of technical services supplied by TIs is not too low though there is ample room for improvement. Let us take a look at the nature of services used by the firms. Table 1 below provides information on ranking of services on the extent of usage.

*Table 1*
**Ranking of Services on the Extent of Usage**

| Services | Used by No. of Firms (%) | Rank |
|---|---|---|
| Standards/testing | 88 (73%) | 1 |
| Education/training | 81 (67%) | 2 |
| Information services | 80 (61%) | 3 |
| Problem solving/trouble shooting | 75 (62%) | 4 |
| Technical networks | 66 (55%) | 5 |
| Commercial advice | 52 (43%) | 6 |
| Collaborative R&D | 30 (25%) | 7 |
| Contract R&D | 24 (20%) | 8 |

From the ranking of services we find that standards and testing, education and training, and information services are the most used services. Commercial advice, collaborative R&D and contract R&D are the least used services.

This pattern of TI service usage by firms as evident from the mail survey is corroborated by an interview survey of firms (purposively sampled to ensure a spread of firm size and variety) in the same industries. The interview survey revealed weak R&D collaboration between firms and TIs. Only 20.5 per cent of interviewed firms collaborated with industry associations, 14.5 per cent with research association, around 8 per cent with general R&D institutions, 14.5 per cent with specialized R&D institutions and around 20 per cent with technical collages (Chaudhuri and Dixit, May 1994).

The weak link between industrial firms and TIs in the area of collaborative and contract R&D is very evident; however, the foregoing discussion also points out strengths of the TIs in the areas of standards/testing, education and training, information services, problem soiving and

trouble shooting and technical networks.

In the following sections we examine the cases of a few TIs which have been successful in developing relationships with industrial firms on a sustained basis or are in the process of doing so and finally draw some lessons for TIs.

## Select Case Studies of TIs

**Generic TI Under Government Department: Institute for Plasma Research**(Chaudhuri, et.al, April 1994)

The Institute for Plasma Research was established in 1986 as an autonomous research institute by the Department of Science and Technology, Government of India to pursue experimental and theoretical studies in the field of high temperature magnetically confined plasmas.

The Institute is active on a broad canvas of fundamental studies of the plasma state. Engineering groups skilled in technologies of Ultra High Vacuum, Pulsed Power, Microwave and RF, Computer-based Control and Data Acquisition and Computer Simulation. IPR has set up the Plasma Processing Group (PPG) to focus on developing plasma-assisted material processing technologies for Indian industry. PPG interacts closely with entrepreneurs through all the phases of technology generation and transfer - from concept to commercialisation.

IPR has developed India's first plasma nitriding reactor for hardening of industrial tools such as gears, cutting tools extrusion dyes. The technology has already been transferred to M/s Indian Plasma System Limited, Gandhinagar, the capital of Gujarat. IPR expects that the first commercial version of the reactor would be marketed shortly. Plasma nitriding is a process which uses only 1/8 of the energy used in conventional salt bath nitriding. It also is a very clean process as it does not use any hazardous chemicals. IPR is currently in the process of developing a number of other technologies: synthesis of aluminium, high value fine ceramic, fine metal and alloy powders, silicon dioxide deposition to produce anti-corrosive properties, barrier coatings

and etching of plastics to increase printability.

Though IPR was set up as an autonomous institute in 1986, it had its genesis within the Physical Research Laboratory, a research laboratory under the Department of Space. Within PRL a group was set up in 1972 to do basic research in the area of plasma physics. In 1982 a plasma research programme was set up within PRL with the objective of expanding the scope of work to include research in the area of Fusion. Finally, in 1986 PRL spun off IPR as a separate institute under the umbrella of the Department of Science and Technology.

PPG's attempts to interact with industry started with (1) dissemination of information about plasma processing and its applications through a news letter published by the Institute called Plasma Processing Update, which is written in a lucid manner. The news letter describes various plasma technologies and their possible applications in a simple language. The Institute wanted to take up for development specific products and processes in which indian industry had already shown interest. Since the institution's resources were limited the selection of the specific developmental activity had to be chosen on the basis of careful analysis of current and future needs of industry. To gauge industry's requirements a meeting was organized in August, 1990 at Ahmedabad with representatives of indian industry to:

a) Identify specific technologies on the basis of industry's needs,
b) Identify expectations of the industry from the Institute in terms of R&D support,
c) Get a feel for industry's commitments to utilise the results of R&D efforts, and
d) Identify strategies for effective and mutually financial interaction between the Institute and industry.

Meetings with industry were organized in four other cities: Hyderabad, Madras, Delhi and Baroda. One indication of increasing interests in plasma technologies is the fact that only 200 copies of the news letter were printed for the first issue, whereas in 1994 IPR was printing about 900 copies per issue, which was expected to go up to 1000 in a short time. The meetings in the

different cities were attended by representatives of 20-25 firms. At the time of this study IPR was planning to organize a national convention on plasma technologies for industrial use.

**Plasma Nitriding Project**

The entrepreneur, who had joined up with IPR for developing the plasma nitriding technology was already familiar with the working of the Plasma Group at PRL as he had worked as an Engineer in the same organization. On leaving PRL he had become an entrepreneur, manufacturing micro-wave RF connectors. This person got interested in plasma technologies through a metallurgist friend of his, who had attended the meeting organized by IPR in Baroda. An MoU was signed between IPR and the entrepreneur. The terms and conditions of the agreement were : IPR would be paid prototype development cost, a lumpsum fee to be paid in five instalments, royalty @ 4% after five years. The agreement was for exclusive transfer of technology. IPR was able to develop the prototype within a year of commencement of work. The Plasma nitriding reactor passed all the tests. The prototype was planned to be scaled up by IPR. Drawings of manufacturing the reactor would be supplied by IPR to the entrepreneur. Another important point to be kept in mind is that the entrepreneur has already done a market survey of the potential of plasma nitriding.

**Frame Work for Plasma Process Technology Generation and Transfer to Industries**

IPR has through interaction with industries over the last few years developed a method of working with industrial firms for the development and commercialisation of plasma technologies. This is described below :

**Task 1: Identification of the Required Technology**

This activity is best done by the potential user of the technology, namely the entrepreneur. This may involve market survey, estimation of financial investments and other inputs, competitiveness with other processes etc. IPR, can, however help the industries in information gathering of the technical aspects necessary to arrive at definitive conclusions of the viability of the venture.

**Task 2: Validation Experiments**

After a specific product or process is identified by the industry as potentially interesting, the basic process know-how has to be developed in a series of activities of increasing technological complexity. However, very often, the confidence in the technical feasibility of the basic process itself has to be established in fairly simple experimentation. Since the entrepreneur may not have the infrastructure to take up this research and development work, IPR would be willing, under extremely fair terms to help the entrepreneur to go through this phase. The basic laboratory facility will be provided by the IPR and the industry will have to provide manpower to help the scientists undertake the R & D work. We believe that this kind of involvement is essential in this phase, as it helps the entrepreneur to develop confidence in the process while helping him to appreciate the technical problems which will have to overcome before full commercialisation of the process.

**Task 3: Prototype Development**

The next phase is the prototype development. This means development of a shopfloor compatible system with most of the automation and safety engineering built in, and meeting with the production requirements, including volume. Since the investments will be reasonably high, the entrepreneur, if he so wishes can take help from technology promotion agencies like the National Research Development Corporation, an autonomous body of the Govt. of India providing venture capital for such tasks.

IPR would provide the technical support for the detailed engineering design, fabrication supervision etc. to meet the required technical specifications of the prototype system. In addition it will work closely with the entrepreneur in the commissioning of the system.

## Laboratories under the Council of Scientific and Industrial Research (CSIR)

**National Chemical Laboratory (NCL)**(Ramnarayan, 1994; Lalkaka, 1996: and Krishnan, 1996)

There are around 40 laboratories under the fold of CSIR. A few such as the NCL, Pune, have achieved world class in a few select fields. The laboratory, established immediately after independence has the mandate to: conduct research in different areas of chemistry, develop new technologies to utilize the country's natural resources, help in import substitution and increasing export potential in the areas of its interest and assist industry in technological development. The current thrust areas of the institution are: catalysis, biotechnology, organic chemical technology, polymers and other high performance materials, and basic research in chemistry and biochemistry.

NCL has achieved considerable success in interacting with industrial clients. One measure of its performance on this front is the ratio of external earnings to total income. In 1994-95 NCL's external earnings amounted to 36.6 per cent of total income. This, however, was achieved over a considerably long period of time.

During the first phase of its evolution from its inception till the mid-1960s NCL emphasized basic research reflecting the orientation of the directors and scientists who had previously worked in universities.

In the next phase the focus shifted to research on short-term applied research with a view to developing processes for industrial chemicals in keeping with the government's economic policies that encouraged import substitution. NCL introduced policies for (a) identification of projects, (b) internal coordination, (c) planning and programming, (d) techno-economic evaluation of projects, and (e) transfer of technology to industry.

During the third phase beginning with the mid-1970s, NCL started emphasizing the need to accomplish major breakthroughs and efforts commenced to achieve a blend between basic and applied research. NCL achieved a breakthrough in the field of catalysis with the commercialization of the encilite-1 catalyst in collaboration with IPCL in 1985. By the end of 1987-88 the laboratory's external earnings stood at 18.9 per cent of total income. The pressure to increase earnings from services rendered to industry was strengthened by the recommendations of the Abid Hussain Committee which suggested that the CSIR finance a third of its expenditure through sponsored research.

Several major changes came about after 1989 when a new leader, Dr. R.A. Mashelkar, currently the Director General of CSIR, took charge as the director of the laboratory. The new direction that he attempted to give to NCL could be encapsulated in two key concepts: (a) international competitiveness in technology development and (b) excellence in basic research.

Major steps taken by NCL since 1989 that have had a considerable impact on its performance vis-a-vis relationship with industry are briefly described below:

1. In 1990 the Project Planning and Development Unit (PPD) was set up under the director, to give a thrust to NCL's interaction with industry and to achieve internal consistency between different activities. PPD's functions included: (a) gathering information on clients' technological needs and conveying the same to scientists; (b) arranging meetings between firms and appropriate divisions within NCL; (c) acting as the commercial agent for NCL.
2. The same year a new scheme was started to support `crazy' ideas on a competitive basis.
3. In 1991 the NCL Research Foundation was set up with financial contributions from industry to provide recognition and give cash awards for outstanding group and individual efforts in development and commercialization of technology.
4. In 1992 NCL negotiated a loan from The World Bank to upgrade its infrastructure including pilot plant facilities.

5. NCL established relationships with multinationals like General Electric and Du Pont. These have helped the organization to (a) upgrade experimental techniques, (b) improve its knowledge of patents, and (c) improve project review techniques.

6. In 1993 NCL received a grant from The World Bank to commission a consulting organization, Generics of the UK, to help in developing a management system to integrate its R&D activities with business strategy and marketing. The grant also covered training of personnel. A budget and expenditure control system was designed and implemented. Authority for incurring expenditure was delegated to project leaders and a project record management system was introduced.

**Private Research Organization**

**Shriram Institute for Industrial Research**[2]

The Shriram Institute for Industrial Research is a private research institute founded by late Lala Shriram, one of the well-known industrialists of the country. The institute has had a very chequered history. It was founded in 1944 and was headed at that time by Dr. S.S. Bhatnagar, a very well-known Indian scientist, who was later to become the head of the CSIR. The institute had a very interesting genesis. Lala Shriram felt that for the economic development of the country it was essential to build-up scientific and technological skills. However, he felt that the research should be directed towards industry's needs, which he thought could be achieved only if it was set up with the help of funds contributed by trade and industry. He himself gave Rs.9 lacs and also some free land for the setting up of this institute and was able to mobilise some additional funds from a few other industrialists. The institute was named after Lala Shriram by the shop-keepers, who had together given him whatever they could to create this institute.

The period 1974 to 79 was a very painful period for the institute. It did not have funds to pay salaries to the employees, who became unionised. The situation became so difficult that the CSIR

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[2] Based on discussions between the author and Late Dr. Nigam, the then Director of SRII.

was on the verge of taking over the institute. However, negotiations fell through. At that time the late director Dr. Nigam who was to become the director working in a private sector firm. He was invited to head the institute as the Joint Director. The new director was given full reins to turn around the institute.

A number of actions were taken by Dr. Nigam. It was decided that anybody who was identified as surplus in the organization would have to leave. Perquisites enjoyed by senior scientists had to be given up. The organization decided not to use any peons, sweepers, security-men, gardeners, typists etc. A major decision was taken to employ scientists against retirement of people at any level. For routine jobs it was decided to recruit graduates instead of people with masters' degree. In 1979 out of 300 people in the organization 75% were supporting staff and remaining 25% were scientists having masters and doctoral degrees. By 1994 the ratio had completely changed. At the time of this study 75% of SRII's personnel were scientists and only 25% were supporting staff. The sales turnover of the organization in 1994 was around Rs.6 crore, which was a major jump from a turnover of Rs.50 lac in 1978.

The services which SRII provided in 1994 included information-services, toxicity analysis, testing services, project irradiation. The institute was in the process of setting up a computer-aided design centre in Bangalore. Another unit for manufacturing ultra pure chemicals required in micro quantities was also being set up. These ultra pure chemicals are very high valued items sold in quantities of grams. The philosophy of technology development of the organization is "not to do technology package development but to fill up gaps."

**Sector Specific Institution**

**Centre for Development of Advanced Computing (C-DAC)**(Chaudhuri and Dasgupta, 1995)

This institution was established in 1988 to design, develop and deliver super computers by the Department of Electronics (DoE). The reason for setting up this institution was that the

technology for supercomputers was not available to the country from abroad thus hampering the development in various fields (e.g. meteorological forecasting). It is a generic type of technological institution set up as a scientific society in line with the Centre for Development of Telematics (C-DoT) under DoE, thereby giving it greater autonomy in its decision making than the CSIR laboratories. But all the R&D activities of the TI were funded by DoE as its output was considered to be of national importance and because of its large requirement of funds, which was unlikely to be funded by private parties. Part of the funds came from contract R&D and manufacturing. Thus government influence existed in funding support and determining the broad research and technology agenda.

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

The institution's technical activities were directed towards strategic R&D with focus on industry's future needs than on basic and academic R&D. This was visible in the greater importance attached to practical achievements in evaluating the performance of its technical staff and negligible importance attached to academic achievements (publications). In working towards its mission the institution kept itself abreast of the latest technological developments in the world which could be put to use by it. Its practical achievement orientedness was evident in its technology acquisition/development strategy whereby it first tried and used existing solutions, failing which it attempted to get technology from outside and finally attempted to develop technology on its own. This was due to the fact that the institution's mission was to get technology faster to the user. This strategy paid off. The institution was able to develop a state of art parallel computer PARAM in the first 5 years of its existence. It was also able to transfer GIST products, for multilingual technology for commercialization.

Out of its total 160 staff, about 110 were technical staff whose average age was low. This was its greatest asset. The success of the institution lay in its management and culture. A problem solving approach with its researchers given leads to follow as well as the practice of assigning specific study tasks ensured that projects were well directed. The informal work culture cut down the bureaucratic wrangles and thereby ensured timeliness. Pride in their achievements and the knowledge that they were the technological "torch bearers" motivated the staff in their efforts. Also motivation was derived from the emphasis given to practical achievements in evaluation.

For developing its internal capabilities the institution placed emphasis on "homegrown" technology based on worldwide technological trends. Technology induction was mostly through study of literature. For training its own staff the institution had its own training school - Advanced Computer Training School (ACTS). It also had a lot of interaction with external institutions, both public and private which acted as co-developers. It used private firms for manufacturing and marketing facilities which it did not have.

It also had a lot of interaction with its clients whose feedback it took in developing its next generation of products. To be more market oriented the institution was planning to use market research to determine its products.

**National Centre for Software Techniques (NCST)**(Chaudhuri and Dasgupta, 1995)

This institution was established in 1985 as a national software laboratory by the Electronics Commission. It had its genesis as a group set up within the Tata Institute of Fundamental Research (TIFR). The TIFR environment in which it was born provided it with the culture of accountability, international orientation and autonomy, which other labs lacked. Government grants constituted 30% of the income, while the rest came from the sale of services. The primary missions of the institution were to carry out research and development in software technology, undertake educational and training activities and support industry through R&D. The organization

had a strong applications orientation towards industry while basic research was not given much importance. This was evident in the evaluation of technical staff where more importance was given to practical achievements than academic ones. It defined its role as a leading edge assimilator of technology for its industrial clients.

To keep up its technological level it acquired the latest facilities in technology in terms of computing hardware, communication and library facilities. To update the technical capabilities of its personnel the institution organized training under UNDP fellowship for specific projects, sent people to international computer manufacturers for training and arranged courses, workshops and conferences in India by invited experts.

To keep itself abreast of the latest technological developments 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 centre at Bangalore, created a 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 did not see a change in its objectives but believes that 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 development. The institution was found to be quite successful and was referred to by most of the software firms for technological needs the low publicity that the institution enjoyed, notwithstanding.

## Cooperative Research Association

### Ahmedabad Textile Industry's Research Association (ATIRA)[3]

ATIRA owes its origin to the vision of two industrialists of the city of Ahmedabad. who were able to mobilize financial support from the Mill Owners' Association in the city and that of the central government. They were also successful in securing the support of some influential scientists. Conceived as an industrial research organization to subserve the technological needs of the composite mills in the city it has undergone a major change in its raison-de-etre because of dramatic changes in the structure of the Indian textile industry. From the very beginning ATIRA's basic objective has been to apply the methods of science and technology to improve the capability and output of textile mills. The specific objectives have, however. changed overtime depending on developments in its external environment.

Has it been successful in achieving its basic objective? To answer this question is not easy. What criteria should be used to measure the performance? In the absence of clearly identified and measurable criteria one may consider several important aspects of the organization in assessing its performance: growth in membership, services rendered to industry, performance in the area of research and development, financial performance, and self renewal capability.

Growth of membership is an important measure of performance. It is a measure of the faith of industrial organizations in a technology supporting institution. ATIRA has been fortunate to have experienced steady growth in its membership. However, one needs to dig a little deeper to understand the dynamics. The original profile of ATIRA membership has undergone considerable change. Whereas in the beginning the entire membership consisted of composite textile mills, today the founding group constitutes only about 35% of its members. Does it mean that the original founders have withdrawn support due to dissatisfaction with the services provided by ATIRA? It may partly be true for some of the organizations. But a large majority resigned from

[3] The case study is based on published information, annual reports, and discussion with senior scientists of the organization.

their membership of ATIRA because of financial difficulties they were facing.

In the initial years services did not account for any significant income. However, over a period of time ATIRA has been very innovative in responding to emerging needs of member mills. From the very beginning the management of ATIRA considered developing a close relationship with its member mills a critical activity. Hence the activities that they undertook from the very beginning were designed in such a way that they required constant interaction with member mills. From almost the very beginning ATIRA started bringing out on a monthly basis abstracts of latest developments in textile science for the benefit of the member mills.

One must remember that the concept of industrial research organizations was very new when ATIRA was set up. Therefore it was a very uphill task that ATIRA had to undergo in winning the industry's confidence. In the beginning technical services provided by ATIRA included routine physical and chemical testing, assessment of work load, and training for quality control etc. Over time ATIRA's scientific and technical personnel have acquired competence to provide a variety of services to industry and policy making bodies. From time to time it has attempted to provide new services in accordance with emerging needs of industry whilst at the same time it has discontinued not so popular ones.

Problems tackled by ATIRA as part of its consultancy services have varied from transient shopfloor problems to surveys of mill operations, planning of renovation, modernisation, expansion and planning of new mills, comprehensive performance analysis, optimisation of performance of various departments, and energy conservation, etc.

In recent years consultancy in the areas of pollution control, defect analysis and development of process control systems for minimising value loss, assessment and calibration of expensive laboratory instruments, and customized information packages, have been introduced.

Other services include inter-firm comparisons of financial performance, costs, productivity, staffing patterns, yarn and fabric quality, etc. A variety of training programmes for different levels in order to update knowledge and competence and promote a professional culture. Workers, jobbers and supervisors, are given attitudinal training and demonstrations of proper work methods with respect to their levels. Organizational restructuring and top management role clarification also forms a part of its capability portfolio.

ATIRA has also conducted programmes for technologists and top management on technical subjects using a variety of pedagogical methods.

ATIRA has developed a comprehensive range of testing services for fibres, raw materials, intermediate products, and finished goods. It has created a specialized laboratory for testing of selected machinery accessories and spares.

Product and process development has been an important activity at ATIRA. A variety of instruments, machinery accessories and control systems have been developed which can be directly used by industry. More than 40 such developments have been licensed to industry.

Research and development at ATIRA covers a very wide range of activities from basic research to applied research and development. Oriented basic research has been considered very important by ATIRA as it can lead to a better understanding of the properties of textile materials and also help in injecting rigour and sharpness in applied research. Basic research covers fibre physics, textile chemistry, and chemistry and chemical modification of starches and gums. Most basic research at ATIRA has been possible through extra-mural funds provided by the CSIR and other national institutes, US Department of Agriculture and other international organizations. As a result it has tended to decline in times of resource scarcity in the funding organizations. The relative decline in the importance of basic research has been alluded to in the previous sections. One indicator of this is perhaps greater emphasis over the last 2 decades or so on recruitment of

technologists/engineers with Bachelor's or Master's degrees rather than Ph.Ds. from top world class educational institutions as in the initial years of ATIRA's development. Of course, this change of orientation has its good obverse side when looked at from industry's perspective. ATIRA over the years has become more attuned to industry as evidenced by the nature of work done and the consistent increase in the earnings from various kinds of services.

The issue of balance between basic and applied research and development is very critical for an organization like ATIRA. Prolonged deemphasis of basic research, which ostensibly started as a result of financial difficulties may have a debilitating effect in the long run. There is already a feeling amongst the larger and relatively more sophisticated textile firms that they do not gain much from organizations like ATIRA as they feel they themselves are technologically at a higher level. This may or may not be true. But the perception is a reality. Unless ATIRA is able to strengthen its activities supported by generation of new knowledge it would tend to become less relevant to the technology oriented larger firms. The longer this situation continues the greater would be the challenge to bring about a change in orientation.

Over the years ATIRA has exhibited an ability to manage its operations in a condition of financial stringency barring short periods of relative abundance of financial resources when major infusions of funds were received. In the area of financial performance ATIRA's experience has varied over its history. During its early period ATIRA was dependent to a great extent on grant-in-aid from the central government though industry support mainly through membership subscription was also substantial. A regime of financial stringency began in the early sixties when the support from the government was reduced and become uncertain. Fortunately other international agencies provided support through research sponsorship.

ATIRA responded using a variety of actions: not filling vacancies, cost reduction, partial reorganization and enhanced attention towards income generating activities like consultancy and testing services, sponsored research, and licensing of new product and process know-how. These

steps helped ATIRA diversify its sources of income considerably and weather the storms it faced. One document - 40 Years of ATIRA - brought out in 1987 stated that over the period 1972-87 membership subscription accounted for 28%, government grants 28%, sponsored research projects 21% and services rendered 23%. These ratios have undergone further change. By 1992-93 membership fees constituted 17.80% of total income, government grant 25.30%, sponsored research 31.9% and income from services and licence fees 23.80%.

These figures speak for themselves. ATIRA has successfully diversified its sources of income and decreased its dependence on government grants considerably. Not only that it has been successful in generating a significant amount of funds through specific projects tailored to customers' needs and through services rendered.

ATIRA has also exhibited a capability for self renewal. Beginning with a strategic planning exercise in 1974 which involved only a few selected persons it has undertaken several comprehensive reviews at 5 year intervals which resulted in the redefinition of its philosophies, objectives and strategies. Actions stemming from these comprehensive reviews have enabled ATIRA to respond to major structural transformations of its client industry.

**Implications for TIs**

What lessons can we draw from the previous sections? Obviously, drawing lessons from a disparate set of cases is fraught with many difficulties. Nevertheless an attempt is made to discuss some implications for TIs that emerge from the cases.

1. Scientific and technological institutions in India are passing through a difficult period due to the financial stringency imposed on them as a consequence of the government's adoption of the New Economic Policy in mid-1991. For many the challenge of raising a third of their revenues from client sponsored projects is a tall order. But it is evident from the success stories of some TIs that developing relationships with industrial clients is not an impossible task.

Success has been achieved by a variety of TIs operating in high tech environment to catering to industries based on moderately sophisticated technologies. The TIs themselves were of various types: ranging from fundamental research institutions to cooperative research associations focused on an industry. Successful TIs seem to develop strategies that are unique to their situations. There does not exist one best method of developing partnerships with industry. However, there seems to be some common elements across the case studies of effective TIs. These are identified and discussed in the following paragraphs.

2. Ownership does not seem to be a critical variable explaining TI success in building sustained long term interaction with client industries, however, it might influence the character of interaction. NCL's thrust is on high science, high technology and international competitiveness; SRII's motto is "a deal a day" with an emphasis on short term problem solving and provision of services that enjoy economies of scale; while ATIRA's focus is on a mix of activities including technology development and providing short term services for process optimization, productivity and quality improvements with the balance tilting towards the latter. Evidently the three TIs had very different orientations. NCL is a governmental laboratory under the CSIR; SRII is a private research organization and ATIRA is a cooperative research association; the latter two having strong industry orientation. It may be surmised that strong representation by industry in the committees responsible for developing TIs' research, technology development and service provision plans might be a useful organizational practice for facilitating partnership with industry.

3. A paradigm shift from offering readymade technologies to a collaborative mode of identifying client needs, developing and transfering of technologies is likely to improve the effectiveness of TIs.

4. For TIs new to the game of developing partnerships with industry it may be useful to initially focus on short term problem solving, process optimization, training and education and

information service. This would enable the TI to get an entry into the technology service market. Gradually with better understanding between the TI and the industry and a higher credibility for the former it may be possible for it to move into more sophisticated areas like collaborative and contract R&D.

5. In situations which demand a missionary orientation, radical changes in policies, major changes in an organization's vision and orientation or response to apparently stupendous odds in technology development as exemplified by the cases of ATIRA, NCL, SRII and C-DAC the quality of leadership is of utmost importance.

The role of leadership is critical in articulating a clear mission for the TI, communicating and imbibing the organization with values consistent with its mission, mobilizing and motivating key constituencies, building the necessary capabilities and developing and introducing necessary management systems.

6. Transition from a technology push paradigm to a collaborative technology development paradigm would require TIs to acquire skills in marketing, interacting with industry, generating and managing funds in a more sophisticated way; instituting new planning and control systems; building a new culture that emphasises achievement of results rather than adhering to rules and procedures, etc. TIs would have to invest in training and development activities in various areas to acquire the new skills.

7. In the long term TIs would need to arrive at a balance between serving industry's immediate needs and building capabilities for meeting industry's future requirements for new product and process development. In the context of an increasingly performance oriented environment that is simultaneously characterized by considerable uncertainty TIs may benefit from using formal strategic planning to evolve their objectives and strategies.

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