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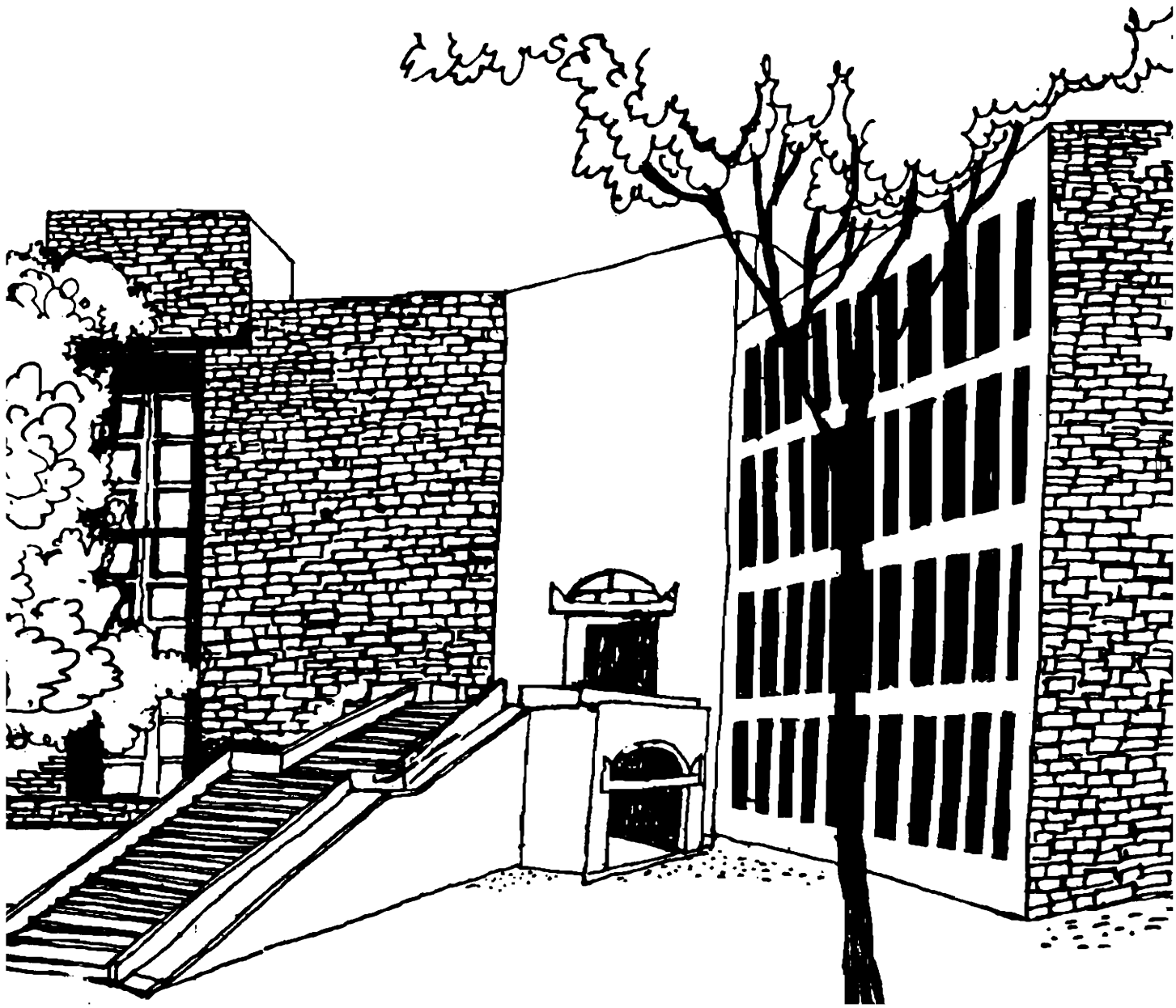

Institutional Infrastructure for Industrial Technology Development in India

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Institutional Infrastructure for Industrial Technology Development in India

Over the four decades since independence India has developed a diversified and well spread-out portfolio of scientific and technological institutions in the private and public sectors at the national and regional levels. Those institutions which existed prior to independence were reorganized to meet new requirements. Attempts were made to strengthen them to enable them attract scientists and technologists. Besides attempting to rejuvenate existing institutions, efforts were also launched to create new ones to address newer areas of science and technology.

This paper presents an overview of the various scientific and technical institutions in India and their characteristics to provide a feel for the country's potential on the supply side of technical services. It also presents a brief analysis of their achievements and shortcomings mostly on the basis of existing literature and discussions with persons concerned with Indian science and technology. The major part of the evaluation of the S&T infrastructure has been done through interviews of firms and TIs as well as firm level mail survey. The findings of these surveys are presented in later papers.

1. Major Categories of Institutions

The scientific and technical institutions operating in India can be categorized on the following axes.

Activity Range: Given the demand for a range of services from education and training, basic research to pilot plant production, a technical institution can choose to specialize in a number of ways. For example, a TI can choose to provide information services only. Alternatively it could provide all the services.

Industry Focus: Given the opportunities to respond to the needs of several industries a TI can choose to specialize or offer its services for all the industries. This is shown in the following figure:

Figure 1
Activity Range and Industry Focus

Activity Range	Industry Focus	
	Selective	Multiple
Selective (Narrow)		
Broad		

Based on the above a possible classification of TIs is as follows.

1. Educational and Training Institutions
   - (a) Universities and Higher Technical Training Institutions.
   - (b) Fully Integrated Technical Training Institutions (education, research and consultancy).
   - (c) Colleges and Polytechnics
   - (d) Industrial Training Institutes

2. Research Organizations
   - (a) Autonomous Organization
   - (b) Special Departments/Commissions
   - (c) Institutions directly under Government Ministries.
   - (d) Industrial R&D Departments
   - (e) Cooperative Research Association
   - (f) Private Research Organization

3. Industry Specific Research and Training Institutions.

4. Technical Institutions for Small Scale Industry

5. Technical Consultancy Organizations

6. Information Centers

7. Standardization Agencies

In the following sections a few of the above type of organizations are discussed in some detail.

2. Educational and Training Institutions

Technical education has a significant role in industrial development. Since independence several working groups and committees have been appointed by the government to assess manpower needs for scientific and technological development of the country. Before independence high quality educational facilities for training persons at graduate and post-graduate levels were almost non-existent. In view of the great need to improve and expand such facilities the Government of India established five institutes of technology (IITs) on the lines of the Massachusetts Institute of Technology (MIT) in United States and Federal Technological Institute at Zurich in Germany. These institutions were created to impart instructions in various specialized subjects along with broad based education to help students become mature scientists and technologists who could eventually become leaders in their chosen fields. In consequence of their pursuit of these objectives these institutions are somewhat different from those that existed before. Thus they created faculties in fundamental sciences and various technologies and also humanities and social sciences. These institutions were created under an Act of Parliament as 'Institutes of National Importance'. The rationale for creating these new institutions rather than strengthen existing ones was that such institutions of excellence needed to develop their own identity and culture.

The IITs have more than met the expectation of the country in developing young engineers of the highest calibre. Their joint entrance examination together with their excellent reputation has enabled them to get the best students from school system for their under-graduate courses. These institutions are autonomous and hence do not suffer from interference from the bureaucracy in developing their curricula and method of instruction. They have very well equipped laboratory facilities and highly qualified faculty. Initially these institutions emphasized the education function which was more academic in orientation but have over the past 10 or 15 years become much more industry focussed to provide the students with opportunities for working on practical technological problems through engaging in sponsored research projects. Some of these institutions have also made considerable strides in providing technical consultancy service to different industrial sectors. These institutions have also made significant contribution in the field of research in different fields (Rahman, 1984, p.32; Vadamalai Media, 1992, p.26).

An indication of the quality of students graduating from the IITs is the fact that about 40 per cent of them go abroad for higher studies of which three-fourths settle there permanently. However, at the same time this is an issue of concern.

There are other science and technology related educational institutions which are geared towards imparting education at different levels. Institutions for post-graduate education and research in science and technology are few in number. They offer degrees leading to Ph.D and M.E./M.Tech/M.Sc (Engg).

Besides the IITs, which were set up by the government there are other institutions of repute which were set up by private initiative. Two examples are the Birla Institute of Technology and Science

(BITS), at Pilani in Rajasthan and the Indian Institute of Science (IISc) at Bangalore. BITS was set up by the Birla business group on the lines of the IITs and the IISc was established by the Tata business group. IISc's initial name was Tata Science Institute. Both these institutions have been able to create a strong reputation for themselves. The former runs courses from the undergraduate to doctorate, whereas the latter only postgraduate. Both these institutions have made considerable attempts to forge links with industry with some success.

Some engineering colleges under universities have also made a mark in the field of engineering education. A few examples are Roorkee University, Delhi College of Engineering, Jadavpur University, Institute of Technology, BHU, Visvesvaraya Regional Engineering College, Nagpur, etc.

Table 1
Selected Statistics Related to Technical Manpower

Course of Study (Degree Level)	1983-84	1984-85	1985-86	1986-87	1987-88
Engineering and Technology Colleges (Nos)	191	223	242	253	257
Enrolment in Engineering and Technology (Nos. and Percentage of Total)	153131 (4.6%)	159046 (4.7%)	164261 (4.6%)	169366 (4.6%)	175463 (4.6%)

Source: Department of Science and Technology, *Research and Development Statistics*, (New Delhi), p.68-69.

Over the years both the number of institutions and the enrollment in these institutions have increased. The growth of engineering colleges and schools in the country can be seen from the following table. In 1983 the outturn of BE/B.Sc (Engg), Diploma Holders, BE, Post-Graduate, ME/M.Tech/M.Pharm/ M.Arch and Ph.Ds in engineering/technology was around 23086, 32871, 1372, 244, 3441 and 337 respectively.

2.1 Polytechnics and Colleges

At the supervisor and engineer level there are polytechnics and engineering colleges located in major towns of the country. They are linked to a University in the state they are located in. There are few autonomous institutions also. The curricula of these institutions and overall administration are governed by the Board of Technical Education set up by various states. Both private and government colleges rely substantially on the financial assistance from the state and central governments.

In recent times, the facilities and quality of education imparted by these institutions have been criticized by industry leaders. The Government of India is currently involved in implementing a major plan with the support of World Bank and industry for upgrading the facilities, enhancing the quality of teachers and education in these institutions.

2.2 Technical Teacher Training Institutes

Technical Teacher Training Institutes (TTTIs) have been created to provide in-service training to teachers in polytechnics. There are four TTTIs in the country one for each region located in Madras for the southern region, Bhopal for the central region, Chandigarh for the northern region and Calcutta for the eastern region. A programme is currently being implemented by the Government of India with the help of a soft loan from the World Bank for upgradation of technician education. The programme envisages capacity expansion, quality improvement and efficiency improvement.

2.3 Industrial Training Institutes

At the worker education level there are Industrial Training Institutes (ITIs) that offer training programmes in technical trades. These institutions are located in all parts of the country. There are private institutions that offer short duration certificate courses in very specific trades.

3. Research Organizations

The next category is that of research organizations which are engaged in basic and applied research with minimal involvement in training activities. They, however, organize workshops and seminars on special topics and are recognized as centers for post-graduate research. They undertake research projects generated by their own scientists and engineers, and also those sponsored by the government and industry. They have been able to attract bright people who have had their education in the country and abroad. These organizations have established linkages with similar institutions abroad and some of them are equipped with facilities comparable with international institutions.

Till recently they relied on near total funding from the Government of India, however, in the context of the New Economic Policy (NEP 1991) they have now been urged to look for additional funding sources.

One way to classify the broad types of research organizations which exist today are described in the following paragraphs.

3.1 Autonomous Organizations

These organizations, created as societies receive their entire financial needs from the government. They are self-governing institutions responsible for developing their own rules and regulations regarding research programmes, recruitment of personnel and procedures for resource utilization and accountability. The institutions that fall in this category are: Council for Scientific and Industrial Research (CSIR), Indian Council for Agricultural Research (ICAR), Indian Council for Medical Research (ICMR) etc. These institutions have their governing bodies and research advisory committees composed of eminent scientists as well as ministers.

3.2 Special Departments/Commissions

These organizations were created to cover emerging areas of science and technology. The commissions were created to advise the relevant government departments on broad policies and programmes. The chairman of the commission was made secretary to the department, directly responsible to the concerned minister. Examples of these forms of organizations are the Atomic Energy Commission, Electronics Commission, Commission for Additional Sources for Energy etc. Several departments have been created recently in newer areas; environment, ocean development and biotechnology.

3.3 Institutions Directly under Ministries

Under the Defence Research & Development Organization (DRDO) there are 41 laboratories.

3.4 Industrial R & D Department

Many private and public sector corporations have their own in-house departments to carry out research related to their own activities. Currently, there are around 1200 Companies, which have separate R&D departments.

3.5 Cooperative Research Associations

The textile industry is probably the first industry to have this kind of organization to undertake research for the industry. These organizations have been created by industry with the encouragement and financial support of government. Cooperative research associations have now been created for industries like Automobiles and Auto Components, Cement, Electrical Products, Rubber based industries, etc.

3.6 Private Institutions

There are a number of organizations which have been created in the form of societies, foundations, trusts etc. These organizations have received financial support as well as fiscal benefits from the government.

4. Council of Scientific and Industrial Research

In this section we shall discuss one autonomous organization, the Council of Scientific and Industrial Research (CSIR), which is one of the very important research institutions in the country.

The CSIR, constituted in 1948, is an autonomous body registered under the Societies Act XXI. The objectives of the council are:

1. Promotion, guidance and coordination of scientific and industrial research in India, including the institution and financing of specific research.
2. Establishment or development of and assistance to specific institutions or departments of existing institutions for scientific study of problems, affecting particular industries and trades.
3. Establishment and award of research studyships and fellowships.
4. Utilization of the results of the researches conducted under the auspices of the Council towards the development of industries in the country.
5. Establishment, maintenance and management of laboratories, workshops, institutes and organizations, to further scientific and industrial research and to utilize and explore for the purpose of experiment or otherwise in discovery and invention likely to be of use to Indian industries.
6. Collection and dissemination of information in regard not only to research but also industrial matters generally.
7. Publication of scientific papers and journals.

The society of the council has the Prime Minister of the country as the President. The Director General is the principal executive officer of the council who is responsible for coordinating and exercising general supervision over all scientific and industrial research and other activities of CSIR. The department of scientific and industrial research under the ministry of science and technology provides the administrative link between CSIR and Government of India.

CSIR employs more than 25000 personnel and manages 40 laboratories/institutes, 2 industrial research associations, over 100 extension and poly technology transfers centres spread all over the country.

The research conducted by CSIR laboratories have mostly been commercialized through an organization specially set-up for transfer of indigenous know-how to industries - the National Research Development Corporation (NRDC). NRDC is a public sector enterprise designed to forge a link between research organizations and industry. The major activities of NRDC are: development and transfer of indigenous technologies, development and promotion of rural technologies, promotion of export of technology, invention of promotion programme, and informatics for technology transfer. Most of the technologies licensed by NRDC have been to small scale units (Ministry of Science and Technology, December 1992, p. 42).

5. Industry Specific Research and Training Institutions

Technical institutions set up to meet the specific needs of an industry are not many. Among those that have been set up with this purpose, two types of institutions can be identified. Those that have been set up as cooperative institutions with industry support and those that have been set up by the Government of India with or without the support of industry. Industries that have developed a large base in terms of their locations, product range and technologies have been able to support such institutions.

Central Machine Tool Institute (CMTI), set up in 1961 in collaboration with the Government of Czechoslovakia of in industry specific institute coming up at the instance of the Government of India. Its aim is to develop design and development expertise in the machine tool industry. It has developed facilities for undertaking this task on its own and in collaboration with the industry. It has also set up an information centre to meet the information needs of the industry. Recently it was renamed as Central Manufacturing Technology Institute to reflect its enlarged scope of activities covering manufacturing technology in general. It has also started a membership scheme to augment its financial resources and develop stable ties with the industry. During 1991-92 the institute generated 58.7 per cent of its revenue from services rendered to industry (Ministry of Industry, Annual Report, 1992-93, p.50).

The Automotive Research Association of India (ARAI), set up in 1966, is an example of the other kind. ARAI is a cooperative industrial research organization set up by the automotive industry with the support of government. Its objectives are to support the automotive industry in the areas of product design and development, evaluation of vehicles, engines, automotive equipment and ancillary items, standardization and technical information.

The textile industry was probably the earliest to promote research associations in various regions of the country. The Ahmedabad Textile Industry Research Association (ATIRA) was the first one to come up in the early 1940s. Today there are similar organizations in Coimbatore in the south, Bombay and Surat in the west and Delhi in the north. These institutions offer a variety of technical services including research, training and information.

Another interesting development in recent times is the setting up of a centre for technology by the Auto Components Manufacturers Association of India with the help of the members, Government of India, the Government of Canada. It aims to provide information and technical services to its members and others in the industry. This is a nascent institution set up in 1992.

6. Technical Institutions for Small Scale Industry

Considering the importance of small scale units[1] in the growth of the Indian economy, the Government of India has taken the initiative to set up TIs to cater to their special needs.

With the support of national level financial institutions, state financial corporations, and commercial banks state level technological and consulting organizations have been set up to meet the needs of small scale industries. These state level institutions known as Technical Consultancy Organizations (TCO) render project consultancy, detailed engineering services, technology transfer services and develop industrial sheds for small scale industry. At present there are 17 such organizations located in different parts of the country.

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1 An industrial unit in which investment in plant and machinery does not exceed Rs.60 lakhs: For units exporting at least 30 per cent of annual production by the third year after commencement of production the ceiling of investment is Rs.75 lakhs.

The National Small Industries Corporation (NSIC) was set up under the Ministry of Industry in 1955 to promote and foster the growth of small industries in the country. It was set up to provide wide ranging services from technology transfer to hire purchase for the benefit of small scale industries. NSIC has set up under its aegis five Prototype Development and Training Centers (PDTC) and four sub-centers to provide technical training and technology related services to small scale industries in various parts of the country. They have been set up as multi-purpose institutions aimed at imparting class-room training and practical demonstration in several industrial trades. They are also required to develop specialized training programmes for rural artisans. To help them organize their training center activities, they have been provided with facilities like testing, machining, casting, electroplating and extension. The emphasis is on small scale units. The centers are also expected to develop prototypes of machines, equipments and tools and transfer the know-how manufacturing units for commercial production. An idea of specialization chosen by these institutions is given in table.

These centers have tried to bring in the latest technology relevant for the small scale sector and demonstrate its utility through training and demonstration programmes. One of the PDTCs for example, has set up CNC training center by installing a CNC training machine. Recently they have been recognized as the centers for research and development by the Department of Science and Technology. This enables them to take up independent research projects and introduce new technologies. In addition to training programmes for technicians and workers, PDTCs offer seminars and workshops. They are linked to national and international agencies for taking up research projects.

The working of these centers is on the lines of any central government organization. The heads of the departments are appointed by the government.

Table 2
Role of the PDTCs

Location	Focus of Activities
Okhla (New Delhi)	Machine Tools, Design & Testing, Rural Technology and Computer Applications
Howrah	Plastic Machinery & Instrumentation
Rajkot	Diesel Engine Devp. and Testing, Energy Conservation, Energy, Audit and Wood Working Machine, Alternative Sources of Energy, Sheet Metal
Madras	Leather and Footwear Machinery
Hyderabad	Electronics and Computer Applications
SUB-CENTERS	
Kashipur	Agriculture Implements & Rural Technology
Dindigul (South)	Locks and Leather Goods
Aligarh (North)	Locks and Brass Hardware
Kothagudam	Mining Equipment
Guwahati	Sheet Metal, Wood Working and Enterprise Building
Center for Quality Upgradation of Domestic Elect. Applin. (New Delhi)	Testing of Domestic Appliances

The Small Industries Development Organization (SIDO) under the Ministry of Industry provides a wide range of services that include training, common facility services like processing, testing and tooling, marketing, assistance, etc. to small scale units through a network of 28 Small Industries Service Institutes (SISIs), 30 Branch Institutes, 6 Extension Centers, 4 Regional Testing Centers, 4 Production Centers, and 15 Field Testing Stations, etc.

Some specialized institutions for the small scale sector are:

(a) Central Institute of Tool Design (CITD), Hyderabad,
(b) Central Tool Room & Training Centre, Calcutta,
(c) Integrated Training Center, Nilokheri in the state of Haryana,
(d) Central Tool Room, Ludhiana,
(e) National Institute of Small Industry Extension Training (NISIET), Hyderabad,
(f) NER Center, Guwahati,
(g) Institute for Design of Electrical Measuring Instruments, Bombay
(h) Electronics Services and Training Center (ESTC), Ramnagar (U.P.),
(i) Hand Tool Design Development and Training Center, Nagaur (Rajasthan),
(j) National Institute for Entrepreneurship and Small Business Development, New Delhi, etc.

These organizations provide a wide range of services. For example, CITD caters to the need of small scale industry in the field of tool design, development and manufacturing technology, and training of technical personnel. CTRC essentially caters to the requirements of the eastern region. It helps SSIs through training, consultancy and design, manufacture of plastic moulds, press tools, jigs, fixtures and precision components.

7. Technical Consultancy Organizations

Technical consultancy organizations (TCOs) provide problem solving help to industry. Most of them came up in the 60s and 70s. A study done at the Indian Institute of Management, Ahmedabad (Chaudhuri and Eugene, 1989) pointed out that of the 94 consultancy organizations surveyed 67 were set up during 1957-77. Details of the break-up are given in Table 3.

Table 3
Period of Establishment of TCOs

Time Period	No. of TCOs
Upto 1947	5
1947 - 1957	4
1957 - 1967	32
1967 - 1977	35
1977 - 1987	15
Not available	3
Total	94

Most of these organizations had their head offices in metropolitan cities like Bombay, Calcutta and Delhi. They had also set up branch offices to meet the needs of the various clients.

Table 4 gives the ownership status of Indian TCOs. It may be observed that most of them were in the private sector. In each of the sectors, private and government a larger portion were independent organizations.

The technical consultancy organizations have developed capabilities to offer a wide range of services ranging from pre-investment and feasibility studies to management consulting. The dominant capabilities have been in the areas of feasibility studies, and preparation of detailed designs, engineering, and tender documentation.

Table 4
Ownership Status of TCOs

Type of TCOs	No. of TCOs	Percentage of total
Private	75	100.0
(a) Affiliated to parent company	22	29.4
(b) Independent status	53	70.6
Government	19	100.0
(a) Affiliated to parent company	4	21.1
(b) Independent status	15	78.9

Source: Shekhar Chaudhuri and A. Eugene, "Some Aspects of Technical Consultancy Organizations in India", Working Paper No.813, July 1989, IIMA.

8. Information Centers

The National Information System for Science and Technology (NISSAT), set up by the government, aims to promote and support development of a compatible set of information systems on science and technology. A number of sectoral centers have been built around existing information resources and facilities. These centers maintain a wide range of documents, published and unpublished reports and books, periodicals, and equipment to provide information services on a national scale. The follow up table (Table 5) lists the centers existing currently (CII, 1991, p. xxiii).

Table 5
Sectoral Information Centres

Sector	Institution Responsible for Coordination
Leather (NICLAI)	Central Leather Research Institute, Madras
Food Technology (NICFOS)	Central Food Technological Research Institute, Mysore
Machine Tool (NICMAP)	Central Machine Tools Institute, Bangalore
Drugs and Pharmaceuticals (NICDAP)	Central Drug Research Institute, Lucknow
Textiles & Allied Industries (NICTAS)	Ahmedabad Textile Industry's Research Association, Ahmedabad
Chemicals	National Chemical Laboratory, Pune
Compact Disk (NICDROM)	National Aeronautical Laboratory, Bangalore
Bibliometrics (NCB)	Indian National Scientific Documentation Center, New Delhi
Advanced Ceramics (NICAC)	Central Glass & Ceramics Research Institute, Calcutta

9. Government Support to Indigenous Technology

In the previous paper we discussed the role of the government in the creation and development of a science and technology infrastructure in the country and its evolution over a period spanning almost a century. We discuss here the important measures that have been initiated by the government in the

recent past or those that are currently in vogue for the promotion of and support to indigenous technology.

The Ministry of Science and Technology is the nodal agency of the Government of India for policy, planning and implementation of programmes related to science and technology. There are three departments under its purview viz. Department of Scientific and Industrial Research (DSIR), Department of Science and Technology (DST) and Department of Biotechnology. In this section we shall discus the work of the DSIR which is more closely associated with support for R&D in industry (Ministry of Science and Technology, 1992).

In 1973 the government started giving recognition to in-House R&D units of industrial firms, which is still continuing. This is currently under the purview of DSIR. The objective of this scheme is to provide a facility to firms to import equipment on liberalized terms to carry out R&D work. The number of units recognized by DSIR has increased from 100 in 1973 to 1205 in 1991. In 1991 the 1205 departments employed around 65,000 persons and spent over Rs.825 cores on R&D activities. Research conducted by industrial firms is encouraged by fiscal incentives provided by the government under the Income Tax Act.

The "Technology Absorption & Adaptation Scheme" (TAAS) of DSIR helps industry absorb imported technologies and improve the level of technology in use. Support is provided for developmental expenditures such as for making prototypes, pilot plant, raw materials, consumable, testing, consultancy, and conducting trials. Capital costs are borne by the firms.

To encourage use of indigenous technology the government gives preference to proposals for manufacture of products based on indigenous technology. The government recently introduced a scheme for the promotion and support to indigenous development of capital goods. Through this scheme the government provides partial financial support for activities directed towards import substitution projects.

9.1 Role of NRDC

NRDC finances pilot/demonstration/semi-commercial plants for proving indigenous technologies and for which conventional sources of funding are not easily available. A variety of methods have been evolved by NRDC for this purpose viz. joint development with R&D institutions, joint development with industry, soft loans to industry/entrepreneurs as risk finance for technology development and equity finance in the first one or two commercial plants based on indigenous technologies.

9.2 Role of Financial Institutions

Over the years the Government of India has helped set up a number of financial institutions at the national as well at the state level to provide term finance for R&D activities. Some of the important institutions are the Industrial Development Bank of India (IDBI), the Industrial Finance Corporation of India (IFCI), the Industrial Credit and Investment Corporation of India (ICICI) and Small Industries Development Bank of India (SIDBI), and State Industrial Development Corporations (SIDC) and State Financial Corporations (SFC). The institutions have a variety of schemes aimed at improvement of technological level of industry. For example, IDBI operates schemes such as textile modernization fund, technical development fund, technology upgradation, energy conservation, modernization assistance, and IFCI provides support in the form of technical consultancy services, risk capital, venture capital, technology development and finance and science and technology entrepreneurs' parks. The ICICI, a development finance institution, has done considerable work in the field of industrial technological improvement and development. Some of the programmes in this sphere are: the Programme for Advancement of Commercial Technology (PACT), Programme of Acceleration of Commercial Energy Research (PACER) and the Technology Support Services Programme (TSSP). PACT focuses on the development end of R&D by providing support to selected Indo-US joint

ventures in R&D, PACT support is in the form of a conditional grant upto a ceiling of 50 per cent of the total project cost subject to a maximum of US $ 5000,000. PACER has three components; (a) formation of consortia to undertake market driven technology development, (b) a research award programme, and (c) formulation of strategy for technology development, policy analysis and information dissemination and training. TSSP, supported by the World Bank and Government of India, encourages development of indigenous technologies through increased cooperation between industry and technology institutions in the country.

ICICI has set up the Technology Development and Information Company of India Limited (TDICI) to provide venture capital to Indian hi-tech enterprises. Another initiative is the "Industrial Technology Group", set up in 1988, which directs programmes aimed at facilitating technology upgradation in the small and medium scale units. Industrial clusters with export potential and scope for energy saving are chosen from technology upgradation.

Table 6
R&D Expenditure in Relation to GNP

Year	GNP (Rs Crore) (1)	R&D Exp (Rs Crore) (2)	R&D as % of GNP
1974-75	63051	291.60	0.46
1975-76	66375	356.71	0.54
1976-77	71432	374.16	0.52
1977-78	80698	430.62	0.53
1978-79	87058	528.60	0.61
1979-80	9551	638.54	0.67
1980-81	122571	760.52	0.62
1981-82	142916	940.73	0.66
1982-83	158217	1206.03	0.76
1983-84	185047	1381.10	0.75
1984-85	206445	1781.55	0.86
1985-86	232730	2068.78	0.89
1986-87	258637	2495.87	0.96
1987-88	291789	2936.94	1.00
1988-89	346277	3471.81	1.00
1989-90	397396	3725.74	0.94
1990-91	468426	4186.43	0.89

Source: G.C. Beri, *Research and Development in Indian Industry*, (New Delhi: Concept Publishing Company), 1993, p.28

10. Overall Assessment

India has created an enviable science and technology infrastructure at least by developing country standards. But what are its achievements and failings ? In this section we attempt to highlight some major achievements and weaknesses of the country's science and technology system with an emphasis on science and technology related to industry. Table 6 gives data on national R&D expenditure. It may be observed that R&D expenditure shows a rising trend throughout the period. As a percentage of the country's GNP it shows an increase till 1987-88 and then exhibits a decline. If data for the period prior to 1974-75 is taken into account the record is quite impressive. In 1958-59 India's expenditure on R&D was only 0.18 per cent of GNP and in 1974-75 it was 0.46 per cent reaching 1.00 per cent in 1987-88.

Table 7 provides data on the contribution by the central, state and private sectors to national R&D. It is obvious that the central government by far is the largest performer of R&D in the country. The total contribution by the private sector (industry) is abysmally small. Recent statistics show that R&D investments made by large engineering firms in India with sales greater than Rs.1000 cores range from 0.2 to 0.4 per cent. The picture becomes even more dismal when we compare these figures with that of the economically advanced nations when the range of R&D expenditures varies from 3 to 15 per cent of sales. Dr. R.A. Mashelkar, Director, National Chemical Laboratory in an interview given to the Economic Times bemoaned that inspite of the fact that India was one of the largest manufacturers of bicycles and sewing machines in the world the R&D budgets of these two industries was Rs.84 lakhs during 1991-92 - indeed a pathetic situation.

The break up of the expenditure incurred by the central government shown in Table 8 shows that during 1990-91 research pertaining to industry (CSIR) was only about 10 per cent of the total. Other major areas of emphasis were; atomic energy, defence, agriculture, and space. Total industrial R&D expenditure as a percentage of the total is given in Table 9. From a high of 27.2 per cent during 1980-81 it declined to 21 per cent in 1987-88, then increased again to 24.2 in 1989-90 and again decreased to 23.2 per cent during 1990-91. Over the decade of the 80s then industrial research on the whole shows a declining trend with some fluctuations. The research intensity of industries have been changing as shown by Table 10. Metallurgical, fuels, transportation, and industrial machinery shows some increase in terms of their share in total industrial R&D, though all of the industries demonstrate absolute increase in expenditure. Metallurgical and fuels show considerable increase in share. On the other hand electrical equipment, telecommunication, fertilizers, and chemicals and defence shows declines in their shares, some of them quite large. Drugs and pharmaceuticals have almost maintained its share.

Table 7
National R&D Expenditure by Sector

(Rs. Crores)

Year	Central Sector	State Sector	Private Sector	Total
1958-59	21.78 (95.0)	1.00 (4.4)	0.15 (0.6)	22.93 (100.0)
1970-71	112.47 (80.5)	12.58 (9.1)	14.59 (10.4)	139.64 (100.0)
1980-81	580.49 (76.3)	59.34 (7.8)	120/69 (15.9)	760.52 (100.0)
1991-92	3827.33 (79.2)	371.94 (7.7)	631.47 (13.1)	4830.74 (100.0)

Note: Figures in parentheses are percentages.
Source: Ibid., p.29

Table 8
Expenditure by Major Scientific Agencies in the Central Sector

Scientific Agencies	1958-59	%	1975-76	%	1980-81	%	1984-85	%	1990-91	%
Dept of Atomic Energy	7.76	41.3	53.94	24.1	73.48	16.8	181.52	15.8	281.17	11.27
Council of Sci & Indl Research	5.10	27.1	37.11	16.6	69.00	15.7	126.36	11.0	250.00	10.03
Defence Research & Dev Orgn	1.50	8.0	52.17	23.3	79.70	18.2	37.32	29.3	685.00	27.48
Indian Council of Medical Research	0.51	2.7	3.32	1.5	9.00	2.0	26.06	2.3	43.70	1.75
Indian Council of Agri Research	3.72	19.8	32.94	14.7	97.45	22.2	130.83	11.4	327.00	13.12
Department of Space	--	--	36.67	16.4	56.01	12.87	182.88	15.9	386.22	15.49
Department of Sci & Tech	0.22	1.1	5.25	2.3	40.64	9.3	96.16	8.4	181.14	7.37
Department of Electronics	--	--	2.38	1.1	5.41	1.2	4.11	0.3	24.16	0.97
Dept of Ocean Environment	--	--	--	--	3.74	0.9	41.38	3.6	202.95	8.14
Dept of Non-Conventional Energy Sources	--	--	--	--	4.00	0.9	10.69	0.9	32.26	1.29
Dept of Bio-Technology	--	--	--	--	--	--	--	--	47.55	1.91
Dept of Ocean Development	--	--	--	--	--	--	--	--	31.94	1.28
Total	18.81	100.0	223.78	100.0	438.43	100.0	1149.54	100.0	2493.09	100.0

Source: Ibid., p.30.

Table 9

Industrial R&D Expenditure as a Percentage to Total

Year	Industrial R&D Exp (Rs Cores)	Total R&D Exp (Rs Cores)	Percentage
1980-81	207.06	760.52	27.2
1981-82	254.55	940.73	27.1
1982-83	319.44	1206.03	26.5
1983-84	369.48	1381.10	26.8
1984-85	404.41	1781.55	22.7
1985-86	450.56	2068.78	21.8
1986-87	527.33	2435.40	21.7
1987-88	598.73	2853.07	21.0
1988-89	759.75	3347.26	22.7
1989-90	903.49	3725.74	24.2
1990-91	970.29	4186.43	23.2

Source: Ibid. , p.31

Table 10

R&D Expenditure in Selected Industries as a Percentage of Total R&D (Rs Cores) Expenditure 1978-79 and 1990-91

Industries	1978-79		1990-91	
	R&D Exp	%	R&D Exp	%
Metallurgical	6.87	5.08	93.68	9.79
Fuels	1.48	1.10	73.05	7.63
Agricultural Machinery	2.94	2.17	10.85	1.13
Electrical Equipment	22.87	16.91	150.62	15.74
Machine Tools	2.27	1.68	12.03	1.26
Telecommunication	10.97	8.11	54.12	5.66
Transportation	6.76	5.00	73.26	7.66
Industrial Machinery	3.45	2.55	41.79	4.37
Fertilizers	4.27	3.15	25.23	2.64
Chemicals	18.73	13.85	72.96	7.63
Drugs & Pharmaceuticals	11.75	8.68	76.81	8.03
Defence Industries	21.85	16.16	113.49	11.86
Others	21.04	15.56	158.84	16.60
Total	135.25	100.0	956.73	100.00

Source: Ibid., p.34.

The R&D expenditure of India pales into insignificance when seen in comparison with that of the developed nations on a per capital basis (Table 11).

Table 11
R&D Expenditure in Selected Countries

Name of the Country	Year	R&D Exp as % of GNP	Per Capita R&D Exp in US $
India	1990	0.9	2.76
Australia	1987	1.3	153.85
Austria	1985	1.3	110.71
Brazil	1985	0.4	6.41
Canada	1987	1.4	216.06
Czechoslovakia	1988	4.5	177.43
Germany (FRG)	1987	2.3	523.98
France	1987	4.6	364.13
Italy	1987	1.2	157.64
Japan	1987	2.8	558.80
Sweden	1987	3.0	577.57
U K	1986	2.3	226.83
U S A	1988	2.6	514.70
U S S R	1988	6.2	218.63

Source: Ibid., p.40

Private sector R&D as a proportion of the total R&D expenditure of the country has shown a lot of fluctuation. From 10.46 per cent it rose to 16.33 per cent after a dip during 1981-82 and declined gradually to 11.93 during 1986-87 before increasing to 12.40 during 1987-88. It seems that the period of decline coincides with the industrial and import policy changes in the 1980s (Vadamalai Media, p.54).

During the 80s the number of foreign collaborations signed by Indian companies increased substantially from previous period. In the late eighties payments made for technology imports had increased more rapidly than R&D expenditure incurred by industry (Iyengar, 1992). This trend has continued in the nineties.

Time and again analysts, industrialists, policy makers and academicians have pointed out the bane of Indian R&D - the absence of appropriate linkages between national technological institutions and industry. This has been pointed out by a number of committees set up by the government to evaluate the work of the CSIR.

The divergence between industrial development and the S&T infrastructure is brought out tellingly by some simple statistics. Around 50 per cent of the country's production is based on imported technology. Of the remaining 50 per cent the major chunk is based on adopted and indegenized foreign technology. It is estimated that only about 5 per cent of the country's industrial production is based on indigenous R&D (Economic Times 1991). These views have been echoed amongst others by Lavakare and Gulati (1989), Jain and Uberoy (1993), Patel (1989), Bhattacharya (1988), and Parthasarathi (1994).

We have uptil now seen only the weaknesses. Are there any achievements ? Yes, there are. The fact that about 45 per cent of industrial production is based on imported technology, which has been indigenised and adapted to local conditions is itself an achievement. The ability to scale down plants and the adaptation of processes to locally available materials in the engineering industry is quite

common (Chaudhuri, 1986; Chaudhuri and Moulik, 1986; Desai, 1984). Even in process industries this has been achieved to a considerable degree. Desai (1984) notes, however, that though the ability not only to manufacture products but to build plants to make them is the most common feature of India's technological capability this capability is unevenly distributed across industries.

The concern for efficiency of R&D investments made mostly by the government is important. However, we should not allow us to be completely swayed by the looming evidence of lack of effectiveness on the innovation front.

Even if the numbers are not large are there some signs of a latent innovative capability ? The answer seems to be a resounding, Yes !

Let us examine the evidence Parthasarathi (1994) notes that there are currently at least 40 major professional systems/products in the areas of telecommunication, TV and radio broadcasting, civil aviation, industrial electronics and control systems and computer-based real time systems under commercial production which are based on domestic technology development supported or promoted by the Department of Electronics. Of the approximately Rs.1250 cores of professional electronics production in the year 1985, around Rs.250-300 cores worth of products was based on domestically developed technology (20-22 per cent). In 1986 the corresponding figures were Rs.1800 cores and Rs.450 cores or about 25 per cent.

Parthasarathi also gives the examples of the Mountain Gun, Special Anti-Tank Ammunition, Low Level Radars, Advanced Panoramic Sonar which were developed by laboratories under the Defence Research and Development Organization (DRDO). Examples of domestic innovations have been reported by laboratories and technical establishments under the departments of Space and Atomic Energy. The CSIR laboratories also have had their share of commercialization of technology developed by them. Chaudhuri (1986), Aurora and Morehouse (1974) and Bhatt (1978) have extensively documented one of the most successful innovations related to the engineering industry - the development and commercialization of the indigenous tractor by the Central Mechanical Engineering Research Institute (CMERI) in the face of tough competition from manufacturers using foreign technology.

There have been a number of notable successes related to process industries. The Indian Institute of Chemical Technology, Hyderabad is credited with the development of a number of processes for drug manufacture which have been licensed to manufacturers. The Central Drug Research Institute, Lucknow, though not very prolific in drug discovery has also transferred technology to industrial firms for producing new drugs.

The National Chemical Laboratory has shot into fame for its innovative work in developing a new series of industrial catalysts. These catalysts have been commercialized by United Catalysts India Limited (UCIL) and Indian Petrochemicals Limited. A number of additional plants are currently using NCL's technology[2].

The Indian Institute of Petroleum has done pioneering work in the extraction of aromatics like benzene and toluene from naturally obtained naphtha. The new process, which gives a higher yield than conventional methods has been commercialized by Bharat Petroleum Corporation Limited (BPCL), Haldia Petrochemicals and Mangalore Refinery Limited (Vadamalai, 1992, p.64).

The National Physical Laboratory has developed an indigenous technology for manufacturing high density carbon - carbon composites for the Indian missile programme. The Central Electrochemicals Research Institute (CECRI) has developed titanium substrate insoluble anodes (TSIA) for the

2 Interviews with scientists at NCL

production of caustic soda. It is estimated that almost all caustic soda manufacturers are today using CECRI technology. The know-how for the manufacture of the TSIA anodes has been transferred to three companies (Vadamalai, 1992, p.64).

On the whole the macro analysis of Indian R&D points to a major weakness in its interdependence with industry but at a disaggragate level there are also the silver linings though emerging only occasionally. Even those organizations which have been extremely successful at one period of time do not exhibit the same dynamism and aggressiveness in wooing industry to use their technologies or jointly develop technologies with potential clients. The malaise therefore must surely lie in the system of innovation. In the following papers we shall present the findings of our interview and mail surveys of industrial firms as well as technology institutions.

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