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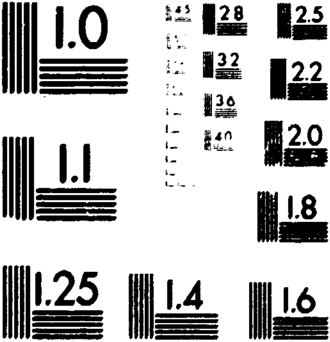

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STANDARD REFERENCE MATERIAL 1010a
(ANSI and ISO TEST CHART No. 2)

Distr.
LIMITED

ID/WG.435/13
16 January 1985

ENGLISH

United Nations Industrial Development Organization

Regional UNIDO/ESCAP Workshop and
National Consultations on the
Commercialization of Research
Results

Bangkok, Thailand, 15-19 October 1984

COMMERCIALIZATION OF RESEARCH RESULTS: EXPERIENCE AND SOME CASE STUDIES OF THE COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH*

by

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V.85-20906

1. INTRODUCTION

Most of the developing countries have established R&D institutions to build up their S&T capability and to provide technical inputs and support to indigenous industries. The performance of these institutions is often sought to be compared with industrial research institutions of developed countries. This is unfair,because firstly, the socio-economic and industrial ethos in which these institutions have been set up are vastly different from those prevailing in the industrialized countries today and secondly, that the output of these institutions is of value not only to the industrial sector but also relevant to the other sectors of the economy and for community welfare as well.

The case of the Council of Scientific & Industrial Industrial Researach (CSIR), India, well illustrates the above points. CSIR has 40 research institutions covering diverse areas of science and technology such as Molecular Biology, Ocean Development, Geophysics etc. and industries such as Chemicals, Drugs, Food, Mining, Electronics, Leather etc. Besides it has five Regional Research Laboratories covering both scientific and industrial research on multi-disciplinary and multi - product basis. Thus the research results of CSIR laboratories are of value to different sectors of the economy such as agriculture, health, public utility systems, rural development, defence besides industry per se.

In the industrial sector CSIR's activities encompass building up of R&D* capabilities, technology generation, assisting industry in the absorption and upgradation of technology, import substitution of inputs, quality improvement, cost reduction, energy conservation, waste utilisation, pollution control, repair and maintenance and trouble shooting etc. The effectiveness of CSIR for industrial development must therefore be judged by the usefulness of its services to the industrial community and the extent to which industry makes use of these services and R&D results. The earnings of CSIR from licensing of knowhow generated are only about $ 1 million a year, whereas the annual cash flow through sponsored (contract) research is around $ 5 million and through consultancy services another $ 2 million.This does not include the training of manpower by CSIR through specialised refresher courses, technical seminars and workshops, testing, repair and maintenance services etc. Thus it would be erroneous to judge the performance of CSIR solely by the earnings from licensing of the knowhow.

Most of the developing countries have embarked on their industrialisation programmes during, the last thirty to forty years. The historical background, the socio-economic ethos and the R&D infrastructure in these countries are different from the prevailing environment in the developed countries at the time of their industrialisation. The developing countries were not even at the take-off stage when the develolped countries were well amidst the industrial

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* Research and Development

revolution. Research institutions form an integral part of this environment and the demands on the type of research services and output and their utilisation are dictated by that environment which itself is a function of historical imperatives and the present day national perspectives and policies.

2. INDIA'S INDUSTRIALISATION SCENARIO

The back - drop for India's efforts in planned economic development and industrialisation was the colonial domination for two centuries which denuded the nation of natural resources, converting an export surplus economy to one of importing finished goods at exploitative prices. At the time of Independence (1947), the Indian economy languished with a rate of growth of agriculture of around 0.3% and of industrial sector below 2%. The Indian industries at that stage were dominated by village and cottage industries. The few industries in the organised sector were confined to processing of agriculture products such as jute, cotton, sugar, tea etc. R&D in industry was unknown - less than twenty industrial units had some facilities for R&D.

In the three and half decades since Independence there has been a significant change in the scenario. India has achieved a real rate of growth of agriculture of about 2.3% and that of industrial sector around 5.5%. The index of industrial production has risen from around 25 at the time of Independence to nearly 160 now, an increase of nearly 500%. Indian industry today possesses width and depth of technological capability and expertise nearly at par with the developed countries. Indian industry today manufactures a vast range of chemicals and petrochemicals, a host of drugs and pharmaceutaicals and nearly all engineering and electronic goods. There are now nearly 1000 industrial units having inhouse R&D facilities spending around $ 300 million a year.

The needs and consequently the priorities of industrialisation have changed over this period. This in turn has propelled the demand and direction of the national R&D system in a particular direction. India's drive for industrialisation, with emphasis on establishment of heavy and basic industries, began in real earnest with the Second Five Year Plan (1956-1961). This was based on imported capital goods and technology, mostly in the packaged form, since the industrial infrastructure and R&D system were then in the nascent stage. The public sector was assigned the role of developing industries in the critical sectors of the economy. It was during this period that over two-third of CSIR laboratories and the National Research Development Corporation of India (NRDC) were established. These laboratories provided to the young indigenous industries back-up suport in metrology, standardisation, testing and analysis, trained S&T manpower and assistance in survey and exploration of domestically availble raw-materials. The sixties witnessed the establishment of down-stream industries with emphasis on import substitution of goods. Although technology continued to be imported, Indian industry had by now acquired the capability to unpackage the diverse components of technology. During this stage, CSIR was able to assist the industry in the solution of day to day technological problems, in absorption of imported technology, import substitution of inputs etc.

In the seventies, India, witnessed a phenomenal growth of small and medium scale industries. This sector now catered to the requirements of inputs of the large industry. By and large, the industrial infrastructure had reached a stage of technological maturity. It was now possible to set up plants based on indigenous technological capability with only minor/marginal foreign assistance. CSIR was also now in a position to offer a number of technologies to the small scale units in chemicals, food, electronics and other areas. Major technologies were developed in fields such as pesticides, glass and ceramics, machinery, leather, instrumentation etc.

In the eighties, the thrust of the industry is towards improvement of productivity and international competitiveness through modernisation and upgradation of technology. This imposes a different set of requirements on the national R&D system. Industry and national R&D system have to join hands and pool their resources to develop technologies to international standards.

3. CASE STUDIES

The research output of CSIR has thus to keep pace and rhythm with the changing national industrial scene. The utilisation of CSIR's research results by industry is thus influenced by multiplicity of factors, which industry or CSIR can neither anticipate nor aspire to control. Each case of successful commercialisation of research results has its own set of unique variables coming together to give a singular solution. However, there are common factors which can be identified as having an important influence on the probability of successful commercialisation. The few case studies given here have been selected to illustrate the interplay of the variety of factors which contribute to the success in commercialisation of research results and the presence of a common thread.

3.1 Titanium Substrate Insoluble Anodes (TSIA)

This is a unique case where diverse favourable factors and circumstances have combined to make a success of the research results.

3.1.1 Genesis

Graphite electrodes are extensively used as anodes in chlor-alkali industry. By end of sixties the consumption of graphite electrodes in India by the caustic soda industry was around 2000 tonnes per annum. There was then only one unit manufacturing graphite electrodes in India. This unit could meet about 35% of the Indian demand. Annual imports of graphite electrodes were then around US $ 1.5 million. The chlor-alkali industry was finding it difficult to procure these electrodes from abroad.

Besides, graphite electrodes suffer erosion and disintegration in use necessitating periodic adjustment and replacement of anodes to maintain the inter-electrode gap constant. In late sixties, Diamond Shamrock Corporation, USA, and Oronzio De Nora of Italy jointly developed Dimensionally Stable Anodes (DSA) which permanently retained their dimensions in use. The Indian industry felt that the initial cost of DSA and the subsequent royalty payment on its use, charged by the foreign licensors, were rather high.

The Alkali Manufacturers Association of India (AMAI), in various forums, desired that indigenous R&D efforts be directed to development of dimensionally stable metal anodes. The government was also anxious that the industry adopts the use of metal anodes, as they saved about 10-15% of power consumed in the manufacture of caustic soda.

3.1.2. R & D

In response to this 'demand pull' from industry, the Central Electro-chemical Research Institute (CECRI) of CSIR mounted a major research effort on development of permanent and stable anodes. Between 1970 to 1971, hundreds of mixed - oxide coatings on a variety of substrates were prepared and their performance evaluated on laboratory scale cells for preparation of caustic soda. Anodes with titanium substrate activated with coatings of mixed-oxide of platinum group of metals were found to give excellent results in laboratory tests.

By 1972 CECRI had filed four patents for Titanium substrate Insoluble Anodes (TSIA).

In March 1972, an assembly of TSIA was installed in a commercial diaphragm cell for field trials. Towards the end of 1973, another two welded structure TSIA were installed in two other commercial mercury cells. These TSIA were operated continuously for several months that provided significant feedback data. Based on these results, four designs of TSIA, each specific to a class of cells were evolved. Thus by early 1974 the development had reached a stage where the research results were ready for commercialisation.

3.1.3. Commercialisation

In early 1974, CSIR assigned the knowhow for TSIA to NRDC for commercial exploitation. A caustic soda manufacturer in whose unit experimental TSIA had been installed realised the commercial potential of these new anodes and sought an exclusive license for their manufacture. Since the government was interested in widespread use of the anodes, NRDC hesitated to license the knowhow on exclusive basis. Around this time, AMAI were so impressed by these anodes that they sought to establish a manufacturing unit for TSIA. Admitedly, an unusual activity for an 'Association'. Since AMAI members were mostly 'large Business Houses', NRDC was hesitent of granting them an exclusive licence.

Independent of this case, in June 1974, CSIR introduced a

'Scientist-Enterpreneur Scheme' to promote enterpreneurship and appreciation of industrial culture among its S&T staff. In this scheme CSIR staff could take time off from CSIR service to set-up industry based on CSIR knowhow. One of the inventors of TSIA sought leave under this Scheme to set-up a unit for the manufacture of TSIA. In this venture he teamed up with the unit which had fabricated titanium structures for CECRI. This was an ideal combination of expertise. As a pioneering venture, the enterpreneurs approached NRDC to invest in the equity capital of the new company. NRDC realised the 'risk' taken by these technocrats and agreed to subscribe 26% of the equity of their company. Thus, after finalising the pre-production matters, the 'Scientist-Enterpreneur' proceeded on leave for period of three years from April 1976, onwards.

In the begining, the new company could not get orders, as the caustic soda manufacturers demanded a performance guarantee for the TSIA. The firm was unable to offer these guarantees. To assist the new company to secure orders, CECRI fabricated and installed a few more TSIA systems. The performance of these systems instilled confidence in the users and the new company began to get orders. CECRI assisted the firm to fulfil these orders by coating TSIA for it. CECRI personnel also assisted the firm in installation, commissioning and troubleshooting problems of the TSIA systems. In 1978, when the firm commenced production, it had already gained valuable experience in the supply of several

TSIA systems. This enabled it to meet the demand for normal TSIA systems. However, CECRI provided the design support and back-up gurantees for new and challenging applications. By early 1980 the firm had achieved commercial success.

AMAI pleaded for licensing more units to manufacture TSIA, to avoid dependence on only a single source of supply and to have price competition. NRDC evaluated the total demand for TSIA and decided to license one more unit. Several industrial enterpreneurs sought license to manufacture TSIA. NRDC laid down stringent criteria for the selection of the new licensee. A large public sector unit having expertise in fabrication of titanium equipment fulfiled these criteria and was licensed by NRDC. CECRI's experience in technology transfer to the first unit helped in quick and trouble-free technology transfer to the new licensee. Within two years this unit, successfully manufactured and supplied TSIA systems.

Foreign intrusion: The 'foreign licensors' of metal anodes attempted to dissuade Indian users from using TSIA under various pretexts. The pioneering unit by its perseverance and aggressive efforts successfully countered these attempts. In mid 1981 as a last resort, a local subsidiary of a Multinational Corporation (MNC) sought to manufacture the metal anodes in financial and tehchnical collaboration of the 'foreign licensors'. CSIR/NRDC opposed the import of technology. High level lobbyng was resorted to influence the government to permit the import of technology. After prolonged assessment, evaluation and analysis of the indigenous technology *vis a vis* imported technology, the government finally rejected the proposal to import technology.

However, the local subsidiary of the MNC was permitted to manufacture the metal anodes under license from CSIR/NRDC. By now nearly 50% of the Indian caustic soda industry have adopted TSIA.

3.1.4. Factors responsible for success

i) 'Demand pull' for technology by industry.

ii) Timely and 'adequate level' technology developed by the research institution.

iii) Inventor as enterpreneur.

iv) Technical capability of enterpreneurs.

v) Risk investment by NRDC in equity capital of the first venture.

vi) Unstinted support and cooperation given by the research institute to the licensees in 'commercialising' the technology.

vii) Perseverance and die-hard qualities of the enterpreneures.

viii) Government support and protection against import of technology.

3.2 High Draught Kiln (HDK)

This case study depicts how external factors - over which neither the research institute nor the industry have any control can make a success or failure of the research results.

3.2.1 Genesis

Brick manufacture in India is dispersed throughout the country and is mostly in the decentralised sector. The present demand for bricks in the country is around 50 billion numbers per annum. Bull's trench kiln, introduced into the country over a century ago, was widely used by the brick manufacturers upto early 1970's. The thermal efficiency of this kiln is low and the heat distribution also not uniform, consequently the bricks are of poor quality. Another disadvantage is that the kiln is operational only in the dry season. As against this, the organised sector used the modern Hoffman's kiln, which was based on imported design, know-how and technical expertise. Although, this kiln was more efficient and yielded bricks of good quality, the high initial cost made it prohibitive for adoption by the decentralised sector.

In 1967 the Central Building Research Institute (CBRI) of CSIR undertook a survey of the thermal characteristics of different Bull's kilns operating in the country. The analysis of the data collected and a study of the kiln operation revealed the basic faults inherent in this kiln. This survey also provided the approach to the development of an improved kiln design, while keeping the capital cost low.

3.2.2 R & D

The CBRI undertook to design a kiln with high thermal efficiency, comparable to the Hoffman's kiln, while maiantaining simplicity of operation. An experimental kiln of capacity to fire, 15,000 bricks per day was set up at CBRI and extensive trials were carried out to study its performance. On the basis of the encouraging results, the experimental kiln was enlarged to produce 30,000 bricks per day. Extensive campaigns were conducted on this kiln to optimise the design parameters. A kiln design called the High Draught Kiln (HDK) was evolved. The HDK effected a net energy saving of over 2000 Million Joules per 1000 bricks besides, giving bricks of improved quality. The slightly higher capital cost of the HDK as compared to a Bull's Kiln paid for itself in a couple of years by saving the cost of periodic replacement of the steel chimneys of Bull's kiln (by use of masonary chimneys and a high draught fan).

3.2.3 Commercialisation

The knowhow for the design of the kiln was assigned to NRDC for licensing in early 1970. In order to promote the wider adoption of this knowhow, NRDC deliberately kept the terms of licence at a paltry $ 300 for the first kiln and $ 150 per kiln for subsequent kilns made by a licensee. Despite these modest terms, NRDC could license only four enterpreneurs till the end of 1972. Owing to the 'energy crisis' of 1973, the cost of energy shot up drastically. Fuel was difficult to obtain and even small brick manufacturers became conscious of reducing costs so as to be competitive with the organised sector. Thus after 1973, over sixty enterpreneurs have taken NRDC licence for the use of HDK.

3.2.4 Factors responsible for success

(i) The single major factor that contributed to the success of this know-how was the energy crisis. But for the phenomenal increase in energy costs, the adoption of the HDK would not have been as widespread as presently.

(ii) The 'technology push' of improved design with the right technical features available at the right time.

(iii) Know-how adequately field proven so that it could be readily adopted by the decentralised sector.

3.3 Electronic Instrumentation for Sugar Industry

This study depicts the success of 'technology push' when the resulting economic benefits are easily demonstrable.

3.3.1 Genesis

Sugar industry is one of the oldest and the second largest agro-industry in India. There are presently over 300 sugar factories in India producing sugar worth around $ 2,500 million annually, employing directly over 3,00,000 workers earning annual wages of around $ 1,000 million. However, this is a traditional industry with very low level of productivity.

The Electronics Instrumentation and Control Systems Group of the Central Electronics Engineering Research Institute (CEERI) of CSIR had by early 1976, successfully developed and transferred the technology for 'excitation control systems for diesel-electric locomotives'. This Group was thus seeking new avenues for R&D - especially for the application of motor controls. It made an initial survey of the 'sugar industry' which revealed the total absence of automatic controls in the manufacturing process resulting in heavy losses of recoverable sugar. CEERI initiated a dialogue with the National Sugar Institute and the government's Sugar Directorate to identify potential process steps whose control would maximise the economic benefits. In 1977 CEERI submitted a detailed technical report of its findings to the Government's Electronic Commission and sought funds from it for the development of electronic control systems for the 'juice clarification stage' and the 'pan boiling stage'. This proposal went through several stages of scrutiny and assessment. In December 1977, the Electronics Commission approved $ 1,40,000 for CEERI to develop these two control systems.

3.3.2 R & D

CEERI initiated R&D work on these two control systems in close collaboration with the National Sugar Institute (NSI). The first prototype systems developed by CEERI were tested out in the pilot sugar mill at NSI. CEERI approached the Sugar Directorate for arranging facilities for the field trials of the equipment. The management of Simbhaoli Sugar factory in the State of Uttar Pradesh who were already toying with the idea of better controlling the process steps readily agreed to try out the CEERI systems in their factory. The initial field performance of the pH control system was not satisfactory; the pH electrodes would scale and foul up in a matter of minutes. Various potential solutions were tried but with limited success. Then as if by accident, a simple solution of cooling the juice prior to sensing and measuring the pH was worked out. The system was modified and tried out in full-scale operations during two-crushing seasons. For the 'pan boiling' controls, CEERI designed and patented a novel method to measure the a.c. resistivity of the massecuite. This was co-related to the level and degree of supersaturation of the mother liquor and was tested in the field for two whole crushing seasons. Both the control systems demonstrably improved the productivity. CEERI periodically submitted technical performance reports to the Electronics Commission. A Steering Committee was set-up by the Electronics Commission to review and monitor the progress of the project. In mid 1980 this Steering Committee recommended to the Electronics Commission that the developments were ready for commercialisation.

3.3.3 Commercialisation

Knowhow generated in projects funded by the Electronics Commission is licensed through Electronics Trade and Technology Development Corporation (ETTDC), a public sector unit. Availability of this knowhow was widely publicised by CEERI and ETTDC in trade and technical journals of the Sugar Industry. Besides, individual letters were addressed to all the sugar factories and sugar machinery manufacturers informing them of the intention to license this knowhow. In response to this about a dozen requests were received for licensing the knowhow. A Group was constituted to decide on the licensing of the knowhow. This group laid down the qualifications of a potential licensee which were:

i) production base for professional instruments.

ii) experience in supply of equipment to sugar industry.

iii) competent personnel and an adequate network to render after sales-service.

The Group also considered the potential demand and decided to license only two units dispersed regionally as well as structurally. Thus the units licensed were a public sector in Northern India and a private sector in Western India. Licensing terms were kept at a modest $ 3,000 only with no royalty payment (price of the two control systems together was around $ 10,000).

Technology transfer to these two units was in a planned, systematic and phased manner. Besides the complete documentation, CEERI trained the personnel of the licensees to assemble and test the prototype equipment. CEERI also assisted the licensees in the installation, commissioning and testing of the first few commercial units. To-date 40 of these control systems have been installed resulting in an economic benefit of around $ 3 million per crushing season for the Sugar Industry.

3.3.4 Factors responsible for success

i) 'Technology push' resulting in demonstrable economic benefits.

ii) Co-operation of industry in field testing the equipment.

iii) Active interest of government in promoting the use of technology.

iv) Careful selection of the licensees.

3.4 Cinema Arc Carbons

This case study presents a fascinating picture of a technology that was lying dormant for several years, due to adverse publicity and monopolistic market position of a multinational corporation (MNC) and then being successfully resurected.

3.4.1 Genesis

The National Physical Laboratory (NPL) was among the first few CSIR laboratories to be established (1950). The NPL pioneered indigenous R&D work on industrial carbon and graphite products. By the end of the fifties,three industrial units had been established based on the technology generated by NPL in this field. In late 1959, a firm requested NPL to develop the technology for Cinema Arc Carbons. The demand for Cinema Arc Carbons, of around 6 million pairs per annum valued at around $ 4,00,000 was wholly met through imports. A tripartite agreement was reached between the sponsor, NPL and

NRDC. NPL was to develop the technology in four stages so that the import content in the manufacture of Arc Carbons could be gradually phased out. NRDC agreed to arrange for the demonstration of the technology at a commercial scale.

3.4.2 R & D

Initially, NPL worked on the development of plating of uncoppered imported carbon rods. This process was developed within a year and the sponsor assisted in establishing this activity at a commercial level. NPL then undertook the more onerous task of optimising on the core and shell compositions. After completing this work, NPL focussed its attention on methods of extrusion of the shells and filling the core. NPL devised and patented a novel method for processing the core and shell materials seperately but extruding them simultaneously. This was a significant improvement over the earlier practice. A pilot plant was established with a capacity to produce about 100 pairs of Cinema Arc Carbons a day. The Arc Carbons made in the pilot plant were sent for user trials. The feedback received from the users helped to further improve the production techniques. A project report for establishing a commercial plant was prepared in 1963. However, a difference arose between the sponsor and NPL/NRDC on the interpretation of certain clauses of the agreement. The dispute was referred for arbitration in 1963. This unpleasant happening demoralised the Scientists and due to the adverse publicity created, dettered other enterpreneurs from utilising this technology.

3.4.3 Commercialisation

In 1961, a local subsidiary of an MNC had sought and received government's approval to import technology from its parent company for the manufacture of Arc Carbons. In line with the familiar MNC practices, the MNC merely plated imported carbon rods in India. Soon, it acquired over 80% of the market share while the rest 20% was shared by half a dozen small and unviable units. In 1966, one of these small scale units sought to import technology for Cinema Arc Carbons. Both CSIR and NRDC opposed the import of technology, since equivalent technology was available indigenously. After detailed discussions and evaluation of indigenous technology the government decided that no further import of technology would be permitted. This small-scale unit had perforce to approach CSIR for the technology. It was obviously an unwilling client. It desired that wider user acceptance be established first. Several hundred-thousand pairs of Cinema Arc Carbons were produced in the pilot plant and sent for user trials. This revived the interest of the industry in the technology. Thus, during the years 1971 and 1972, NRDC granted six licences for this technology, including the small-scale unit who had sought import of technology. This unit even appointed an engineering consultant to prepare the detailed engineering design for the commercial plant. Another licensee was a professionally managed engineering company manufacturing welding electrodes with imported technology. It was entering this line due to the similarity in the manufacturing process of welding electrodes and arc carbon rods. Both these licensees were simultaneously given the same technology package. In addition, NPL Scientist's visited the site and factory of these licensees for on the spot advice. The engineering company was able to commence commercial production in 1975. The small-scale unit had established its production but was unable to achieve satisfactory quality and quantum of production. This was mainly due to the 'family' management of the small-scale unit - where all expertise was drawn from amongst family members. Thus this unit could not achieve success for non-technology reasons. The engineering company fared very well commercially and made a substantial dent in the market share of the MNC. It soon acquired the factory established by the small-scale unit and rectified its problems. Both these units are now successfully manufacturing Cinema Arc Carbons to full capacity and are even exporting them. The same engineering company was even approached by enterpreneurs from abroad for transfer of technology. This illustrates, how a technically competent unit can make a success of a technology which had been dormant on the shelf for even a decade.

3.4.4 Factors responsible for success

i) Government's support against import of technology.

ii) Right technology with user acceptance of the product.

iii) Technical and managerial competence of the licensee.

4. INDUSTRY'S VIEWS

During the last two years CSIR has organised a series of get-togethers with the 'large' as well as the 'small' entrepreneurs to ascertain the attributes needed in 'research results' in order that it be commercialised by them. The following salient points emerged of these consultations:

i) Research projects, of relevance to industry, should be drawn up in consultation with industry on an institutional basis.

ii) The temporal utility and progres of such projects should be monitored by a Group comprising of members from Industry, Consultancy Organisations and Research Institutions.

iii) The research results so generated should be evaluated by independent professionals for their commercial viability.

iv) Feasibility and market reports should be prepared on the knowhow accepted for commercialisation.

v) Well defined qualifications, and criteria for the selection, of a potential licensee should be laid down and publicised.

vi) The knowhow package should be comprehensive and provide adequate information.

vii) Post-licensing services, such as, visits and deputation of technical personnel, should, be provided by the research institutions.

viii) The risk of the 'pioneer licensee' should be under-written.

5. CONCLUSIONS

i) It should be clearly recognised that industry is just one amongst the many beneficiaries of R&D carried out by S&T research institutions in India. Industry derives benefit from the research activities of these institutions in diverse ways, licensing of knowhow being just one of these. Thus, judging the performance of these research institutions on the basis of their 'licensing activities' alone is unfair.

ii) The adoption of laboratory research results by an industrial enterprise in a developing country is vastly different from its adoption of technology acquired from another industrial unit. The former involves greater risk taking and requires higher levels of technological capability than the latter. Both these qualities are scarce among the entrepreneurs in developing countries as compared to their counterparts in developed countries.

iii) The risk borne by a 'pioneer licnesee' in commercialising laboratory knowhow is not confined to the cost of knowhow alone but to his entire investment cn the project. The normal commercial guarantees on performance merely cover part of the knowhow fees. The initial lumpsum knowhow payment for technology licensed by CSIR is less than $ 5,000 in over 85% of the cases,whereas it is 10 to 20 times higher for similar technology imported. Even then it works out to just 3 to 8% of the projct investment. Thus there is no significant reduction in the risk borne by a licensee commercialising labortory research by pricing the technology modestly. Participating in the equity capital of the 'pioneering venture' is the only pragmatic way of sharing the risk.

iv) Small and medium entrepreneurs are the main users of domestic laboratory research. Over 85% of CSIR's licenseees belong to this category. These entrepreneurs lack the resources to acquire technology from abroad and perforce have to seek it from within the country. By their inherent limitations they seldom have the capability to extrapolate and upscale the laboratory level knowhow. The case studies also indicate that the closer the R&D gets to commercial/field proving of technology, the brighter are its prospects for commercialisation. Thus, for technologies of potential interest to small entrepreneurs, laboratory R&D should be taken as close to commercial level as feasisble.

The large firms who have a high degree of technological capability are not enthused by the domestic labortory technology as they have the means and resources to avail of technology from abroad. The adoption of domestic laboratory technology should be made more worthwhile/beneficial for the large firms through the following measures:

(a) Relaxation of physical controls.

(b) Provision of monetary/fiscal incentives.

v) As revealed in the case studies here, government's support and protection to domestic labortory technology against import of technology has influenced the chances of its success. However, this should not be left to chance but formalised in a country's technological policy.

The Government of India announced a comprehensive Technology Policy in January 1983 to cover not only the manufacturing sector but the agricultural and service sectors as well. The basic objectives of the Technology Policy are: development of indigenous technology and eficient asborption and adaptation of imported technology. The Technology Policy also enivisages support for development of indigenous technology to achieve technological self-reliance and reduce dependence on foreign inputs, particularly, in critical and vulnerable areas and for high value-added items with a strong domestic base. Further it lays stress on the provision of incentives to users of indigenously developed technology and for products and processes resulting from such use.