R&D COMMUNITY- ENTERPRISE COOPERATION

IN TECHNOLOGICAL RESEARCH AND COMMERCIALISATION OF RESULTS

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D PACIFIC CENTRE FOR TRANSFER OF TECHNOLOGY

REPORT

ASIA-PACIFIC REGIONAL WORKSHOP ON

R&D COMMUNITY - ENTERPRISE COOPERATION IN TECHNOLOGICAL RESEARCH AND COMMERCIALISATION OF RESULTS

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PREFACE

The experiences of developed countries indicate that technological changes have occurred mainly as a result of interactions between enterprises, research and development (R&D) and market forces. The nature of cooperation between enterprises and research institutions has taken diverse forms complementing the purposes and priorities of both. Thus with a view to strengthen such linkages and to promote cooperation among developing countries of the Asia Pacific region in this field, APCTT in cooperation with UNCTAD and national agencies organised a workshop on "R&D Community-Enterprises Cooperation in Technological Research and Commercialisation of Results", from 7-10 November 1994, in New Delhi, India. The main purpose was to share the experiences and views of enterprises, associations, R&D institutions and evolve suitable mechanisms to enhance commercialisation of R&D results in the region.

The programme covered four topics: (i) Factors influencing the performance of R&D organisations; (ii) Issues concerning application or commercialisation of R&D results in selected sectors; (iii) Encouraging greater utilisation of locally available R&D options; and (iv) Diversity of experiences and possibilities of furthering multi-country and multi-enterprises partnerships. Each session had a keynote speaker followed by presentations by experts from member countries. Based on the discussions, specific suggestions were made and one of the recommendations related to the evolution of a "Regional Association for the Commercialisation and Application of R&D Results (RACORD)". This type of regional networking was emhpasised primarily to cater to the technological requirements of small and medium enterprises (SMEs) in the region. The valuable opinions and suggestions of the participants at the workshop will be reflected in our future programmes.

We are grateful to the Special Unit for Technical Cooperation among Developing Countries (SU/TCDC) of the United Nations Development Programmes (UNDP) for the financial support provided for the implementation of the programme and to the rapporteurs Mr. S.N. Sharma and Dr. Sudeep Kumar, Scientists, Technology Utilisation Division (TUD), Council of Scientific and Industrial Research (CSIR), New Delhi who worked diligently to prepare this report under the guidance of Dr. H.R. Bhojwani, Head, (TUD), CSIR. We express our appreciation to all those who have contributed in one way or the other to the successful organisation of the workshop.

I hope this report on the workshop will be useful to enterprises, R&D institutions, consultants and other promotional agencies both within and outside the Asia Pacific region.

April 1995

Dr. Jürgen Bischoff
Director

CONTENTS

Presentations

Executive Summary and Recommendations

The transition between research and the utilisation of its results is one major weakness of the innovation system in developing countries. It was by successfully interlocking technology imports with domestic endeavours, thus creating "virtuous circles" of economic growth and technological advancement, that some countries have been able to initiate a more sustained development process. While it is difficult for most countries to be at the forefront of technological advancement, they should ensure that they do not lag behind too much and are not totally marginalised from the interactive process of economic growth and technological change. Against this backdrop, the workshop discussed and deliberated individual country experiences and mutual cooperation.

The performance of R&D organisations has been influenced by factors, external as well as internal, that yary from country to country and from time to time. The major external factors comprise: overall technology climate in the country, financial resources devoted to R&D, infrastructural facilities, availability of knowledgeable staff and policies aimed at facilitating the evolution and application of R&D. The internal factors are: managerial practices; staff remuneration and motivation, R & D experimental facilities, technology marketing and information dissemination mechanisms.

The expenditures for research and development as a percentage of GNP vary widely in Asian countries, ranging from 0.13 to 2.3 per cent of GNP, and it is thus difficult to establish comparisons as regarding the level of performance of R&D organisations. Diverse economic agents intervene in the technological innovation process. It is, therefore, important to create an integrated technological system rather than deal with isolated elements of the technology innovation chain.

Regarding the intemal factors influencing the R&D organisations, there is need for good management, strong local ties, continuity of funding, attractive salary systems, and a system of awaras to stimulate local R&D. In some countries of the region, the brain-drain from R&D organisations into other spheres of economic activity is an issue of major concern.

The R&D community, as a supplier of technologies has a major role to play, along with enterprises, in generating value addition and thus in revitalising economic development. The interaction between enterprises and R&D organisations in the developing countries is weak. In several instances a good investment climate has been created, but the enabling environment addressing research and development and the utilisation of technologies and results has not been altogether satisfactory. Efforts have however been made by countries to improve the arrangements for and mechanisms of financing physical investment and to establish venture capital facilities in connection with task oriented R&D (for example in Korea).

The government, even in a market economy situation, has an important role to play in technological development through the formulation and implementation of coherent technological policies, although, the private sector constitutes an essential element of economic growth. Indeed market friendly policies help address a number of specific issues and suitable country or inter-country approaches help in overcoming problems of smallness of size of enterprises and of countries, and their resource constraints. Governments should provide an economic environment favourable to the development of enterprises, and assure prudential standards or frameworks for the conduct of different kinds of business matters. Suitable arrangements and institutional mechanisms for the promotion of technological development and application should be established.

With reference to the institutional arrangements in some of the countries, R&D endeavours are carried out through independent organisations or undertakings whereas in others, the research centres are part of the academic system as in the case of the Research Centre for Applied Science and Technology (RECAST), Nepal. Thus, there is need to strengthen the infrastructural facilities including those for maintenance and repairs of R&D machines and equipments as well as the number of technicians and researchers in order to attain a basic threshold level of R&D infrastructure. Some of the problems particularly encountered by least developed countries of the region relate to lack of adequate national commitment as well as a perceived need for new technologies, poor infrastructural facilities for R&D, smaller market size, market communication problems, unfair competition, etc. Frequently R&D is undertaken without conducting market research and ascertaining the demand for the end product. In this context, a survey undertaken in one of the developing countries revealed that the R&D activities carried out in five productive sectors such as food processing, metal, wood, rubber and electronic products were not based on the actual needs of the enterprises and as such had no commercial potential. Technology transfer is a multistep process and adopting technology to market needs involves evolving suitable technology transfer relationships. Technology marketing is necessary to strengthen national capabilities in specialised areas such as technology evaluation and assessment as well as in technology negotiations. There is considerable scope to promote technical cooperation among developing countries in these areas.

There are a large number of elements for supporting and enabling infrastructures for R&D-enterprise interaction. These include technological information, intellectual property protection, standards, quality control, engineering and design organisations, technology licensing and process, equipment maintenance, venture and risk capital, facilities of marketing of R&D results and human resource management. One suggestion could be the creation of a regional association for the commercialisation of R&D results (RACORD). The commercialisation of R&D results involves several actions and synchronisation of interests between R&D institutes, technical consultants, financing institutions and enterprises. Very often the R&D results have to be combined, encompassing one or several of the following factors namely, (i) machines/knowhow; (ii) material/energy; (iii) manpower/management; (iv) money/financing; (v) marketing. The combination of various elements could be assured by a laboratory, an R&D organisation, an engineering and consultancy enterprise, or by the user of technologies themselves.

The changing technology context can be expected to continue its accelerated pace in the 1990s and beyond. This requires that developing countries adopt new forms of cooperation to meet the challenges ahead. Such forms have to aim at the creation of broad-based entrepreneurial and technological capabilities, and stress aspects concerning the transfer, adaptation and dissemination of technological advances. In the first instance, priority might have to be given to the facilitation of catching-up on standard modern technologies. More than ever, there is a need to underline the critical importance of intensifying interactions between public R&D institutions and the enterprise sector, involving all the diverse economic sectors.

The most advanced industrialised economies have utilised specific policy mechanisms in support of science and technology - for example, direct grants to universities and research institutes, typically in their pursuit of basic non-competitive research, programmes of cost-sharing of R&D projects of enterprises, specific allowances for accelerated depreciation of product development costs, selective government procurement schemes, and other forms of promotion of technological change. Governments have also encouraged R&D collaborative ventures among firms. Policy instruments to this effect range from financial support to cover externalities, to partial relaxation of anti-trust legislation, favouring the pooling of resources. It is generally accepted that government policies supporting R&D and its absorption could yield a high social payoff. Such social payoffs would occur in those contexts in which investors did not undertake all projects whose total benefits (as opposed to only those expected to be privately appropriated by them) were expected to exceed their costs.

In addition to the pursuit of domestic policy mechanisms, there has been a trend towards concerted international cooperation in the technology area. Such cooperation has been induced either by purely private concerns, exemplified in enterprise R&D collaboration ventures, or as cooperation spurred by international programmes specifically designed to facilitate international technology cooperation, in an attempt to speed up technology driven growth and development. There are some factors leading to domestic as well as international technology cooperation including the mounting costs, in terms of both human and financial resources required for science and technology. In some very costly fields, particularly those with major equipment requirements, cooperation is no longer a matter of choice but of absolute necessity, and to grant priority at the national level would be synonymous with deciding to participate in an international effort as a result of national priorities. The continued growth of development costs is compounded by the shortening of product cycles, which imply rising financial risks associated with innovation, and with the utilisation of R&D results by enterprises in particular, small and medium enterprises. These forces lead to cooperation not only as a means to sharing R&D costs but also because in many instances markets are required to be substantially larger than those that could be provided by a single medium-sized economy. Otherwise, a smaller market would require a longer period to amortise the R&D investment, which in turn involves much higher risks as other producers could enter the market on the supply side. Hence, the growing trend of strategic alliances between enterprises also focuses on marketing and distribution agreements.

In a situation in which free market forces and increased liberalisation were due to occur, new policies, institutional arrangements and human resources development programmes had to be devised. Among the short-term goals of policy, there was an increased utilisation of indigenous research and the reduction of dependence of R&D institutes on government grants. Among the long term goals of policies, there was an increase in private sector involvement in public R&D, as well as an increase in private R&D undertakings. The problems at present include a very large number of relatively small research institutes, limited efforts in applied R&D, poor commercialisation practices, negligible budgets for R&D purposes, poor private sector interests in R&D, supply driven public sector R&D, poor staff motivation, weak marketing, and lack of pilot plants for technology evaluation and testing. A comprehensive technology policy, which would respond to these realities is required. This also means an increase in the budget for R&D activities. These activities should be more commercially oriented which means that they should essentially be market driven, without displacing longer term research efforts that may not have a direct application in the economy but constitute the backbone of technology advancements. The marketing of R&D results and an appropriate budget for undertaking R&D is required. An increased participation of the private sector in product oriented R&D, as well as the involvement of private sector representatives in the boards of R&D institutions, might be beneficial in the implementation of technology policies. All this would make local R&D results more attractive to financial institutions and venture capital companies. At present, financial institutes perceive greater advantages in utilising imported technologies rather than looking for locally available R&D results. A revolving fund intended to support indigenous technological development efforts such as pilot plants, demonstration programmes, training activities etc. could be a viable solution.

The challenges and opportunities for R&D undertakings differ from one sector to another, as well as between countries. The requirements of the marketplace are likely to be met through various modes of operation, among which feasibility studies, demonstration programmes, and technical consultancy services could play an important role. Discussions revolved around a range of issues concerning R&D and commercialisation in key technological areas with reference to biotechnology and environment friendly technologies. References were made to the need for cooperation and evolving strategic alliances in the commercialisation of specific technologies through long term multi-product partnerships, joint ventures, as well as research partnerships at the pre-competitive level. Emphasis should also be given to creating enabling institutions for strengthening linkages between government, enterprise sector and research institutions.

In view of growing concerns about environment degradation which is common in many countries in the region, it makes sense to introduce environmentally sound technologies. These technologies are also important to enhance the competitive edge of countries in the region. Environmental considerations should be integrated in the process of technological innovation and in particular in the process of R&D and commercialisation of results. Most developing countries have R&D installations in sectors such as food processing, construction, pollution abatement, waste recycling, utilisation of agro wastes, renewable sources of energy, health, use of biotechnologies, new materials, etc. In this connection, sectoral economics need to be studied carefully, and the longer term trends emerging from the impact of new technologies on economic patterns have to be analysed in the decision making process by policy makers, R&D undertakings and entrepreneurs. Since funds for R&D are scarce in most developing countries, R&D cooperation could be strengthened in order to obtain optimum results from available resources. National and regional seminars need to be organised in order to examine the possibilities and instrumentalities for facilitating the application of research results by small and medium enterprises. In addition, a detailed analysis of contractual arrangements between enterprises, and with research organisations, should be prepared for discussion at specialised workshops. An agenda for cooperation encompassing food processing and preservation, materials handling, upscaling process demonstrations, training centres for operators, advisory and consultancy services was suggested including multi-country and multi-enterprise arrangements and national, sub-regional, regional and inter regional initiatives. The specific recommendations made were :

1. Since R&D expenditure as a percentage of GNP is not adequate for comparison of level of performances of R&D in developing countries, select country experiences might be studied to evolve new indicators for comparison. APCTT should initiate such a study.

2. Generally R&D funds are scarce and as far as possible, developing countries might avoid duplication of S&T efforts by utilising facilities that exist in the region. These could be utilised on a cost-effective basis.

3. APCTT could explore the possibility of evolving mechanisms for R&D cooperation in priority areas such as agro & food processing, housing and building materials, waste management, advanced materials, energy conservation, etc.

4. In the endeavour for publicly funded R&D institutions to be market driven, basic research should not be ignored as it forms the bedrock for application and industrial R&D.

5. Publicly funded R&D needs to be more market driven. Thus, APCTT should facilitate the organisation of regional workshops and training programmes to enhance the manpower capabilities for technology marketing.

6. With a view to promote transfer and utilisation of environment friendly technologies in the region with the emphasis on small and medium enterprises, APCTT should organise select technology demonstration programmes in cooperation with R&D institutions and associations of industries.

7. To facilitate regular interactions between organisations of the region for promoting regional cooperation in the commercialisation of R&D results, an association could be set up with the cooperation of the secretariat of APCTT.

8. R&D institutions lack funds for setting up pilot plants to facilitate commercialisation of indigenous technologies and also to assist small scale industries. APCTT could explore the feasibility of setting up joint pilot plants in select areas with the active participation of enterprises in member countries at the subregional and regional level.

9. APCTT should initiate case studies on R&D investments in various sectors of industries of the region and analyse the impact of such investment on economic growth.

10. Consultants and consultancy organisations are important elements of the innovation chain to convert R&D efforts into commercial investments. APCTT should create a database on consultants and consultancy organisations of the region and disseminate information to R&D organisations as well as technologies. APCTT could facilitate exchange of data in the region.

11. R&D by industry should be made an attractive proposition in itself in developing countries and in order to encourage the utilisation of indigenous

R&D capabilities and technologies, the governments of the various countries need to introduce attractive incentives for industry in the form of tax benefits, excise duty concessions, etc.

12. Small and medium scale enterprises (SMEs) lack access to : (a) information on the type of technology required; and (b) technology capabilities existing within the country and outside. APCTT should evolve a strategy for assisting SMEs in technological and financial aspects relating to technology transfer.

13. Venture capital plays an important role in the utilisation of laboratory developed technologies. Governments could encourage private venture capital companies by giving appropriate incentives to such companies.

14. R&D should become an attractive career, and scientists should be recognised and rewarded. APCTT could suggest a system of awards for excellence in technology development and transfer in cooperation with member countries.

15. A handbook, to be discussed in a seminar, as a basis for training courses for research personnel on methods of patenting domestically and abroad should be prepared.

16. A compendium as a basis for the training of research personnel on mechanisms and modes of contracting between research organisations and enterprises should be developed.

17. APCTT could consider organising national workshops to study alternate models for R&D community and enterprises cooperation in restructuring their national technology development programmes.

Inaugural Session

The workshop was inaugurated by Dr. S. Z. Qasim, Member, (Science), Planning Commission, Government. of India. Distinguished speakers in the inaugural session included Mr. Cheng Ruisheng, Ambassador Extraordinary, Embassy of the P.R. of China, Mr. Ali Reza Sheikh Attar, Ambassador Extraordinary, Embassy of the Islamic Republic of Iran, Mr. Bayani S. Aguirre, Sr. Dy. Resident Representative, UNDP, Mr. Ashok Parthasarathi, Additional Secretary, Department of Scientific and Industrial Research, Govt. of India, Ms. Aurelie von Wartensleben, Senior Economic Affairs Officer, ECDC Division, UNCTAD and Dr. Jurgen Bischoff, Director, Asian and Pacific Centre for Transfer of Technology.

Dr. S. Z. Qasim in his inaugural address congratulated APCTT, UNCTAD and UNDP for organising such an important workshop that would provide an opportunity to the representatives of the participating countries to learn from each other's experience in the areas of technological research, cooperation, commercialisation and application. In the present context any technology developed must be globally competitive. To achieve this, it required constant updating of knowledge and skills for which a strong R&D base was needed. Dr. Qasim stated that modern technology was not robust machinery oriented but was system software based and was becoming obsolete fast. He explained that in most of the developed countries, investment in high technology areas was enormous. India could not currently afford to invest so much in technology development but the country had a very strong S&T base which could be utilised systematically for achievements in the fields of high science. Dr. Qasim felt that the workshop would play a catalytic role for sharing of technologies among the countries of the region. He wished the deliberations all success and was hopeful that the workshop would come out with some innovative approaches that could be implemented in the region for R&D community-enterprise cooperation.

Mr. Cheng Ruisheng in his address said that the need for R&D community-enterprise cooperation, technological research and commercialisation/application of results could not be over emphasised. He said that the workshop was most timely and should come out with concrete recommendations which should be effectively implemented for the benefit of the participating countries.

Mr. Ali Reza Sheikh Attar in his address said that the workshop would provide a good opportunity to the scientists of the Asian and Pacific region to exchange views and enrich their knowledge. He felt that countries of the region suffered from an ever increasing technological gap compared to the developed world. Mr. Attar hoped that the deliberations and conclusions of the workshop would provide some inputs to the intellectuals and policy makers of these countries to liberate themselves from the devastating wave of economic backwardness. He suggested that the Third World countries need to politically determine their long term R&D projects with a view to increasing the scientific temperament of the society and its material benefits and quality of life. He felt it was important that science regain its position among the people and the policy makers. Adequate fora should be provided for interaction of scientists at regional and global levels, he said. Mr. Attar said that during the past few years, some major steps had been undertaken in the Islamic Republic of Iran in this direction. The literacy rate had gone up from 51 per cent to 73 per cent during the last fifteen years; the proportion of students opting for science and technical courses had increased by more than 60 per cent; R&D expenditure was 0.6 per cent of the GNP and for every one million population, 25 persons were engaged in research activities; research projects were mostly in technical fields (32 per cent) and least (14 per cent) in humanities; each production unit was obliged to devote 0.2 per cent of its sales revenues for research activities or divert the same amount to a general research fund. The industrial research budget had increased from 32 per cent of the total research budget in the past 12 years to 46 per cent. The Ministry of Industry had established 120 R&D units which were responsible for computerisation of manufacturing processes and resolving day to day technical problems in factories. The Ministry of Industry also planned to enhance the linkages of research and production units and to establish homogeneous research centres for the same kind of industries. Presently, four such centres for 45 industries have been established.

Mr. Bayani S. Aguirre in his address mentioned that UNDP had been supporting numerous S&T projects in India in diverse scientific areas. UNDP's endeavour had always been to assist technology upgradation in the region. He said that an evaluation of UNDP funded projects in India had recently been carried out which revealed that these projects could generate a variety of benefits. However, some lacunae were also noticed among which "lack of coordination between end user and contributors of research results" was most significant and merited immediate attention. He stressed that research results should be effectively utilised for the overall development of society and that technology should reach people. He wished that the workshop deliberations would be able to add newer dimensions to the subject of technology development and transfer.

Mr. Ashok Parthasarathi commented on the topicality of the workshop and felt it was of importance to all developing countries including India. He complimented UNDP for the study on the UNDP projects in India and endorsed the study's finding that user interaction in the UNDP projects was not generally effective. He stated that technology in the sense of knowledge to do a task had always played a major role in the economic and social development of a country. He explained the mechanism by which the Department of Scientific & Industrial Research (DSIR) was taking technology to industry and to the market. Mr. Parthasarathi stated that strengthening different components of the innovation chain was important to take a product from the bench level to the user. He said that the key features of the chain were interfacing and amalgamation of interdisciplinary technical skills and these must be inculcated in the educational system. Mr. Parthasarathi was of the view that innovations could not be commercialised by playing it safe, since taking commercial/technical risk was part of entrepreneurship. Mr. Parthasarathi stated that the Asian and Pacific region had great diversity in the field and much could be learnt from each other's experience. He thus felt that the workshop was most timely and it should focus attention on issues of mutual interest.

Ms. A. von Wartensleben expressed the hope that the workshop would open up new avenues for multicountry cooperation, and create new opportunities for interaction between the R&D institutions and the enterprise sector, particularly small and medium enterprises, for technological advancement. Such cooperation, could enhance the economic growth process, improve its sustainability, and help assure a more human development process. She thanked Mr. A. Parthasarathi, Additional Secretary at the Ministry of Science and Technology, for various suggestions intended to avoid the erosion of R&D expenditures. She acknowledged the lively interventions of the Chief Guests, Mr. Cheng Ruisheng, Ambassador Extraordinary of China, and Mr. Ali Reza Sheikh Attar, Ambassador Extraordinary of the Islamic Republic of Iran. The inaugural address by Dr. S. Z. Qasim, Science and Technology Planning Commission, having underlined such aspects of technology development as interactive policy decision making, modern forms of management, improvements as regards the application of R&D results, computerised systems, and improved partnership arrangements, might respond to rapid rates of obsolescence characterising the current technological paradigm. The technical sessions would certainly be inspired by the statements made during the opening session. The participation of senior executives from enterprises, from R&D institutions, from financing corporations, as well as the presence of the specialised press, were valued very highly.

Dr. J. Bischoff in his address explained that most developed countries were presently in a phase where their attention was focussed on deriving the maximum benefit from the third generation of cumulative technological advances whereas some developing countries in the Asian region were still struggling with putting in place rudimentary technological changes to enable them to improve productivity and thereby stimulate economic growth. Dr. Bischoff attributed the refined pace of technological change in developed countries to the effectiveness of interaction between research institutions, industry and markets. However such interactions, were either totally missing in developing countries or were there in a non-effective form. The workshop thus intended to provide the participants an opportunity to exchange and share information and practical experiences concerning interaction between the R&D community and enterprises with the objective of helping the countries to enhance the efficient application of R&D results and strengthen the market related aspects. The participants would be able to analyse the existing forms of cooperation in other countries and discuss policies for improving the utilisation of R&D opportunities, and strengthen their technological capabilities. Dr. Bischoff said that the issues concerning the nature, directions and intensity of technological change, as well as difficulties, potential and possible orientations concerning the application of research results would also be taken up during the deliberations in the workshop.

Keynote Address

Ms. Aurelie von Wartensleben
Division for Economic Cooperation Among
Developing Countries and Special Programmes, UNCTAD

Introduction

The application of research outputs and results in the production system is difficult and complex. A diverse range of efforts are required to incorporate new technology into the economy. Technological advancements have to meet the needs of consumers, the requirements of producers, the environment and or the society at large. In order to achieve this, governments, as well as enterprises and research organisations have pursued a wide range of strategies and policies, which differ between countries as well as between sub-regions and regions. While all countries might share fundamental values relative to economic growth and development, there are also many plausible reasons and explanations for the diversity in policies pursued. Indeed, such policies not only reflect the multifaceted nature of technology, but also the constraints in the availability of natural, human and financial resources.

Trends in net funding of physical investment in the 1970s and 1980s

It is not possible to establish any one-to-one relationship between government policies and trends in the financing of enterprises. Resources, deployed by the productive sector reflect economic motivation (yields, profits, benefits), as well as social consensus. The advanced market economy countries had evolved highly sophisticated financial institutions, and capital markets, capable of responding to the various short and long terms needs of the users, while simultaneously creating benefits for the providers of financial resources and for innovators.

The retention of earnings provided over 95 per cent of net funding in the United Kingdom in the early 1970s, and less than 40 per cent in Japan for the same period. Loans played a significant role in Japan and in Italy at the beginning of the 1970s, but their role appears to have considerably diminished by the end of the 1980s. Bonds, shares and trade credits have occupied only a minor place in all five countries over the period between the early 1970s and the late 1980s.

In advanced market economy countries, the private sector enterprises are an essential element of economic growth, though the role of government is not redundant. Market friendly policies evolved by governments help address a number of specific issues, and inter-country policies help in overcoming problems of smallness of size and of resource constraints.

Table 1: Trends in net funding of physical investment of non-financial corporations

	Japan		Italy		United Kingdom		Canada		United States	
	Early 1970s	Late 1980s	Early 1970s	Late 1980s	Early 1970s	Late 1980s	Early 1970s	Late 1980s	Early 1970s	Late 1980s
Retentions	39.9	62.1	42.4	71.9	95.7	11.7	68.4	82.2	72.5	10.7
Transfers	0	0	4.5	5.9	6.8	1.7	1.6	1.2	0	0
Loans	51.5	34.5	34.5	14.9	19.6	-7.5	9.2	8.3	16.7	10.5
Bonds	1.7	7.3	3.8	-2.7	1.3	12.9	14.7	8.4	11.5	20.4
Shares	2.6	6	6.9	5	-4.9	-5.5	4.4	6.8	5.6	-22.7
Trade credits	-4.2	-4.2	0	-0.1	1.2	-0.5	0.7	-2.5	-1.7	-4
Other	8.5	-10.3	7.8	5.1	-19.7	-18	0.9	-4.4	-4.7	-11.2
Net Total	100	100	100	100	100	100	100	100	100	100

Source : Applied Economics. Volume 26 Number 5, May 1994.

Modalities and sources of finance for emerging enterprises

Even in market economies the venture capital firms are a relatively small source in the total finances of emerging enterprises. However, their role in helping translate R&D results into practical applications is significant. This, could also be relevant for developing countries, although probably to a lesser extent.

In order to perform the full range of functions usually attributed to the financial and capital markets, there is an urgent need to strengthen the organisational framework for these. Poorer countries and small enterprises, often of an individual or family nature, which are often not well versed in technology matters, as well as unacquainted with financing modalities, are most likely to be bypassed by technological advances and eluded by capital flows. It is to address these situations appropriately that "seed money" is of primary importance for the development of institutions and capabilities for technological upgradation.

Table 2: Sources of funding for research and development in developed market economy countries (1988-1989)

	R&D/GNP	Private R&D/ Total R&D	Enterprise's R&D Total R&D
United States	2.9	48	72.5
Japan	2.9	78	66
Germany (F.R.G.)	2.9	64	72.2
France	2.3	42	58.9
United Kingdom	2.3	49	67
Italy	1.2	42	57.2

Source : Data extracted from Nelson, R.R. (editor) : National innovation systems. A comparative
Analysis. New York. Oxford University Press. 1993.

Technological upgradation and R&D efforts should be an ongoing activity of a long term nature in all developing countries, not necessarily to keep pace with the most advanced technologies, but in order to ensure that emerging local enterprises can rely on locally available institutional capacities and adaptive R&D. This is an essential ingredient of the "supply" side of a nation's technological strategy. Further, national innovation systems vary widely, and so do the levels, sources, and mechanisms of funding, as shown in Table 2, which compares six large (high income) market economy countries.

The average size of enterprises appears to influence the magnitude of R&D carried out, the presumption being that the increasing complexity of technologies makes it impossible for individuals or for small enterprises to engage alone in competitive research and technological development efforts.

Table 3 broadly provides statistics of small and medium sized enterprises (SMEs) in the European Community. Although definitions, as well as tax treatments, somewhat differ from one country to another, yet in all these countries, favourable taxation schemes, as well as simplified administrative treatment, have been accorded to SMEs. All market economy countries have facilitated or accorded special allowances for R&D efforts by enterprises and for collaborative R&D arrangements. This is basically due to the fact that : (a) individual enterprises or economic agents are too small to undertake this; or (b) due to the maturation period which is too long for an emerging enterprise; or (c) due to uncertainties with respect to the practical applicability of the outcome.

In search of arrangements for the 1990 and beyond

No discussion on the emerging arrangements for technology commercialisation for the 1990s would be complete without viewing venture capital as a means for early stage financing for emerging enterprises, even though conventionally venture capital is become quasi-synonymous with risk capital since it involves uncertainties.

Risk capital concerns situations where it is not possible to raise funds from public capital markets due to smallness in size, low stage of development, limited degree of leverage, or the nature of business per se. Venture capital financing addresses itself to such situations and provides for : (i) that part of capitalisation (equity, ordinary shares, common stock) which is not secured by a lien or mortgage (securities); (ii) that part of finance, long term loans, or capital invested in high risk/high yield business activities of a non financial nature; and (iii) that part of investment in common stock from a new, emerging, or significantly changed enterprise.

Table 3: Small and medium enterprises (SMEs) in selected market economy countries (1989)

	Number of SMEs	Population thousand	SMEs per 1000 inhabitants
Germany (F.R.G.)	404,195	62,063	6.5
France	699,170	56,423	12.4
United Kingdom	1005,300	57,236	17.6
Italy	300,000	57,540	5.2
Denmark	85,917	5,132	16.7
Netherlands	257,000	14,846	17.3
Greece	70,824	10,033	7.1
Portugal	171,919	9,793	17.6

Source : Data extracted from Journal Official des Communautes Europenes. 9 juillet 1994.

The sharing of risk is an important aspect of most multi-agent economic situations that arise when the objectives of an activity, or the magnitude or characteristics of the activity itself, are such that they cannot be achieved or carried out by an individual economic agent. There is, therefore, a need to cooperate and to facilitate or support such cooperation as a source of benefit for all participants. The "temporal" view of coordination between enterprises is conceptually quite different from the traditional vertical or hierarchical integration of enterprises through such moves as acquisitions. It is also quite different from the horizontal (or lateral) mergers between firms. Both these forms of enterprise integration could be objectionable when carried to magnitudes or forms running contrary to the prevalent market competition paradigm.

Cooperation in terms of availability and exchange of information between enterprises is likely to enhance the operation of markets in two ways. Firstly, by letting each other roughly know the potential areas of concentration, enterprises themselves discourage over-investment, thus perhaps helping forestall a certain number of failures or even bankruptcies as too many economic agents would move in a similar direction. Secondly, by complementing, and not substituting for, the free interplay of market forces, avoiding disruptive swings or destructive economic confrontation.

Inter-enterprise cooperation (or coordination) is of a temporal nature and is particularly relevant in the context of an unstable or rapidly changing economic (or technological) environment. It is also particularly relevant with respect to many small and medium enterprises whose operations are mutually complementary in that the total benefits (or profitability) of the ensemble are greater than just the sum of its parts brought about in a non-coordinated fashion.

The economic criteria for evolving cooperative arrangements are thus essentially of a dynamic nature, helping firms and enterprises to develop and utilise productive resources, thus increasing the sources of income and wealth, and underpinning the process of development. Within a competitive environment, cooperation or coordination is not a matter of global governance, but rather : (i) the fruitful interchange of information; (ii) the joint search for "empty" economic spaces; (iii) the creation of a plurality of products meeting distinct preferences of the consumer; and, (iv) the filling up of creative R&D areas which the market itself is likely to under-provide due to the long term nature of investments and the relatively undefined profitability expectations of long term R&D.

Some tentative conclusions

The nature of cooperation and coordination between economic agents might vary between countries, as well as between regions and subregions. The current economically variable and relatively changeable situation gives rise to the complexity and diversity of modes of cooperation in the economic domain. The prevailing subregional or regional mechanisms should not be seen as processes of exclusion, but rather as policy responses aimed at smoothening economic cycles and disparities, and globally complementing the allocative and creative functions of markets.

Five aspects need further discussion : (i) increasing the performance of R&D in developing countries in the context of open, outward oriented, economies; (ii) improving the interactions between research institutions, enterprise representatives and policy makers in the context of evolving a new long term partnership consensus of development; (iii) inducing improvements in the financing mechanisms for local technological capacity building as an underlying factor of dynamic economic growth; (iv) devising suitable policies and approaches for technological changes as a route to accelerating economic growth, that is responsive to environmental considerations; and (v) using sub-regional, regional and cross-regional cooperation modalities as instruments for achieving these tasks.

The follow-up activities could then deal with (i) improving information mechanisms and expanding data bases concerning the availability of technologies; (ii) enhancing the advisory functions and information network relating to technologies of particular relevance to emerging small and medium enterprises; (iii) providing advisory services on, introducing or enhancing funding arrangements, including venture capital organisations or associations; (iv) organising short term training and information exchanges on the evolving modalities in capital markets; (v) ensuring the regular organisation of short term training courses, with participation of executives/managers of enterprises, and research institutions, facilitating the transition into economic activities of upcoming research results; (vi) encouraging and facilitating longer term training of technologists, as well as scientists, in specific subject areas where capabilities are weak, or non-existent; (vii) opening up new opportunities for training, encompassing fellowships, as well as the hardware and electronic data processing methods, where appropriate, on technologies and on access to capital markets by small and medium enterprises; (viii) exploring the possibilities for implementing these activities, including the source of funding.

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Part V of the Cartagena Commitment of a New Partnership for Development, adopted in February 1992. Deals with matters relating to economic cooperation among developing countries (ECDC), intra - as well as inter-regionally. Policies and measures in supprt of ECDC are discussed in the context of the work of UNCTAD's Standing Committee on ECDC.

Factors Influencing the Performance of R&D Organisations

Introduction of Theme

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Introduction

The international economy has now become truly globalised and interdependent. As a consequence, impulses effects or policies originating in major economic centres have an impact well beyond national, subregional and regional spheres. The theoretical and the empirical analyses confirm that stagnation tends to create an all-round recessionary trend; similarly, economic growth in one, stimulates successive rounds of development in other parts. In the light of these considerations nations, organisations and enterprises are seeking and encouraging new forms of partnership so as to bolster the universal objectives of sustained and sustainable development.

Broad consideration of factors influencing R&D endeavours

Diverse factors, internal and external, intervene in shaping the path of economic growth, opening up new market opportunities and calling for rapid technological development. The often divergent requirements of consumers and producers, environment and society necessitate multifaceted R&D endeavours and cooperation at intra country and intercountry levels. Even technologically advanced countries have faced problems in their attempts to generate, introduce and absorb new technologies. The challenges of introducing technological advancement are greater, when the level of economic development and the technological base is narrow. In general, the performance of local R&D systems is influenced by the overall level of economic development, availability of financial and human resources, R&D infrastructures and the strategies or policies of enterprises as well as of government.

The setting within Asia in the early 1990's

Statistical data or information relating to developing countries is relatively scanty, especially of those indicators that are of interest to policy/decision makers and to enterprise executives. There is a need to develop more sophisticated methods of determining sources of technology and innovative activities in developing countries. International comparative economic indicators (Table 1) at sub-regional levels could serve as a backdrop to the country presentations.

Table 1: The Asian region in world economic growth and development : In the early 1990's

	Units	South Asia	South Asia excl. India	East Asia	East Asia excl. China	South-East Asia	All deve-loping	All deve-loping
Real GDP per capita	US $	1260	1600	3210	9510	3420	2730	14860
GNP per capita	US $	330	310	650	7190	1000	880	14920
GNP growth rate (60-91)	% p.a. prices const.	5.5	5.5	9.4	9.3	5.7	4.6	3.1
Tertiary graduates	% of age grp.	—	0.6	0.5	—	2.6	1.2	19.2
Scientists & technicians	Per 1000 pers	3.2	2.1	9.7	45.1	9.7	8.8	84.9
Adult Literacy (age 15+)	% of age grp.	47	39.1	81	97	86	69	
Newspapers	Per 100 pers.	2.7	1.2	5.6	28.5	3.8	4.4	30.3
Mean years schooling(age 25+)	years	2.3	2.2	5.2	8.1	4.5	3.9	10.1
Television sets	Per 100 pers.	2.7	1.2	3.7	14.9	6.1	5.5	54.4

Source : UNDP Human Development Report 1994. Oxford University Press. New York and Oxford 1994

Though the real GDP per capita for all developing countries is less than one-fifth that of the developed countries, yet it affords potentialities and opportunities for rapid economic growth; this was evidenced by the fact that over the last thirty years (1960-1991), the per capita GNP growth rate of all developing countries has averaged around 5 per cent as compared to only 3 per cent for developed countries. The increasing levels of development and the booming market economies could be corelated to education of the population comprising : literacy, years of schooling, graduates at tertiary levels and the number of technicians and scientists.

Enhancing R&D endeavours

No set of statistical parameters can adequately measure or describe the diversity of R&D endeavours, their magnitude and their impact. However, traditionally, several kinds of indicators have been utilised for comparing R&D endeavours of countries viz. (i) resource indicators for inputs; (ii) result indicators for outputs; and (iii) impact indicators for socio-economic effects of technological changes. The analysis of factors influencing performance of R&D have in the past concentrated on studying policies and frameworks at the domestic and intercountry levels but currently the focus is on the role of enterprises, with diverse partnerships and synergetic forms of cooperation between them. In developed countries the measures supportive of R&D endeavours have encompassed elements such as tax concessions of R&D undertaken by or through or with enterprises.

While for a specific technological development, the level of inventive or innovative capacity or a stroke of luck or even genius are the contributing factors, on a broader canvas, teamwork and synergistic cooperation are the salient components of technological advancement. Increasing technological complexities led to more cooperation and inter-relation between research organisations and to larger R&D organisations with facilities devoted to a specific area of research. Thus the allocations of funds for such purposes plays an important role in assuring technological advancements and in reviving economic growth. As regards R&D expenditures, the differences between developing and developed countries remain quite large (Table 2). However, starting from a low absolute level, the growth of R&D expenditures in some of the developing countries have been impressive.

Nonetheless, increased R&D expenditures by themselves are not enough to ensure technological and economic development; the efforts made to "bridge" the gap between theory and application by end-users are equally important. The lack of specialised technical services, weak engineering capabilities, and lack of venture capital for covering the risks of technological innovation in developing countries are the key factors that greatly narrow down the outcome of R&D endeavours.

The development of S&T and R&D infrastructure in India, over the past four decades, presents an interesting future. The government had forecast an increase in R&D expenditure to 2 per cent of GNP by the year 2000 (it is presently under 1 per cent), on the assumption that the private sector's contribution to R&D would be significantly enhanced in the future. It was expected that with economic liberalisation, industrial sector would encounter greater competition. To respond to this phenomenon indigenous R&D efforts would have to become more intensive.

The situation of China is not dissimilar to that of India. The trend towards a market economy has created a new environment for R&D endeavours and R&D institutions are adopting a more demand-led approach to technological advancement.

The Republic of Korea started on a development path that initially involved the import of mature technologies. After the establishment of the Korean Institute of Science and Technology (KIST), greater emphasis was placed on creating a base for local R&D. The establishment of specialised institutes followed gradually. Specific factors such as high energy prices leading to a demand for energy-saving devices has accelerated the local technological development process.

In the case of Thailand, it is largely the interplay of market forces, encompassing internal and external aspects, which have forged local R&D endeavours. Thus over time, the number of research institutions, laboratories and higher education institutions have increased, as have R&D expenditures and foreign technological collaborations and payments for imported technologies.

Table 2: Research and Development Expenditures by major sets of Countries

	Units	1973	1980	1988
Latin America	% of total	0.8	1.7	0.7
Africa (excl. South Africa, and Arab countries)	% of total	0.1	0.3	0.1
Arab countries	% of total	0.2	0.4	0.1
Asia (excl. Arab countries, Japan, South Korea)	% of total	1.7	4.1	3.1
Japan and South Korea	% of total	7.9	10.2	19.3
Australia and New Zealand	% of total	1.2	0.9	0.9
Western Europe	% of total	21.6	24.2	25.8
North America	% of total	33.7	31.1	32.8
Eastern Europe and USSR	% of total	33.1	27.2	17.3
World total (at current prices)	US $ billion	97.1	218.1	435.1

Source : Salomon, J.J., Sagasti, F. and Sachs-jeantet, C. (Eds.): The uncertain quest-science, technology and development. UNU. 1994. Tokyo. Page 112.

The countries of the Asian region have been quite heterogeneous in their development. The images of their R&D structures can could only be further sharpened by studying the specific characteristics of the countries concerned, and their intercountry relationships.

Possible shifts and trends beyond the mid-1990's

While the overall distribution of R&D efforts between developed and developing counties has not changed much over time, notable shifts have taken place within the developing world. Countries like India and the Republic of Korea have increased their spending on R&D and are emerging players on the world R&D scene. On the other hand, a number of developing countries have diminished their R&D expenditures, with the prospects of ultimately jeopardising their own sustained economic growth. In contrast, the industrialised countries have maintained their dominant position by strengthening their R&D infrastructure over the past 25 years.

A major feature of the rapid economic growth of developed countries, and that of several developing countries, is their ability to evolve innovative systems that can respond flexibly and appropriately to challenges of change. Indeed, the "localisation" of technological progress is an important phenomenon, which has been addressed in different ways. Thus, in France and in the United States a "mission oriented approach" appears to have prevailed in setting the tone for some of the broad R&D endeavours such as those in the field of aerospace. In Germany, as well as in the United States and Japan, the "environmental policies" of government have set the tone for many enterprise or industry-specific efforts such as those relating to the introduction of lead-free fuel for automobiles. A "diffusion oriented outlook" appears to have predominated with regard to a number of new materials with specific desirable characteristics such as biodegradable plastics for bottling and packaging industries.

The need for enterprises (particularly the smaller ones), and research institutions of the less advanced countries, to search for more effective local forms of cooperation and interactions in their R&D endeavours is quite obvious. The economic growth achieved by several of the Asian countries opened up opportunities for such cooperation. Such a strategy would imply that the governments devise suitable policies and mechanisms for the establishment of indigenous technological capacities, and for facilitating the translation of results from R&D endeavours into practical applications.

The transition from research to utilisation of results appears to be the weakest point of the innovation system in developing countries. But some of the countries by interlocking technology imports with domestic endeavours, that is, by creating "virtuous circles" of economic growth and technological advancement, have been able to initiate sustained development processes. Venture capital funding corporations and associations can also play a role in this regard. While it would be difficult for most countries to reach the forefront of technological advancement, it was important that they do not fall too much behind, and are not totally marginalised from the interactive process of economic growth and technological change.

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Promotion of Linkage and Performance of R&D Organisations : Indonesian Case

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Introduction

Indonesia has been successful in establishing an industrial system to produce goods and services for domestic as well as export markets as also in setting up a number of R&D organisations and universities. But the linkages between the two systems are relatively poor. However in the second long term development program, which started in 1993, conscious efforts to promote cooperation between industrial enterprises and R&D community have been taken up. The building of linkages between the industrial and R&D systems is an integrated program covering not only the demand and supply sides but also technology support facilities and national technology climate.

Issues and problems of linkages in Indonesia

(a) The industrial sector

Industrial growth in Indonesia can be attributed to accelerated and intensive promotion of foreign and domestic investment. The contribution of manufacturing industries in total GDP has increased from 14.4 per cent in 1985 to 21.2 per cent in 1991, to become greater than the contribution of the agricultural sector. The total manufacturing output was valued at about US$ 12 billion in 1985 which increased to US$ 35 billion in 1990. Most enterprises were developed based upon policies of import substitution, strengthening of industrial structure in terms of upstream - downstream linkage, market opportunities, creation of job opportunities and utilisation of local materials. In many cases technology was considered to be a part of the capital investments and thus technology capability building in the perspective of an enterprise's management still needs to be promoted.

(b) The research and development sector

Over the past 25 years government has consistently invested in developing research and development units, S&T manpower etc. The R&D system can be grouped into: non-departmental institutions; ministry / departmental institutions; universities and higher learning institutions; public enterprises; and private sector institutions. Traditionally, most R&D institutions were in the government sector and they were constrained to follow the administrative rules and regulations of government offices and civil servants. A new learning process is underway to transform the attitude of government funded units to those of active innovation service units. However, despite the political will and the growing needs of enterprises on indigenous S&T services, the transformation process will not be an easy task. This needs concerted effort to build effective partnerships between industry, R&D organisations and other supporting units.

(c) Support facilities and technology climate

Effective linkages between enterprises and R&D organisations require several specialised support facilities such as financial and venture capital; engineering (design, workshops, construction); metrology, measurement and testing; and S&T information. These facilities are now being promoted in Indonesia but are still in their infancy.

Factors influencing the performance of R&D units

There are several interrelated factors that contribute to the performance of R&D units in Indonesia.

(a) Internal to R&D units

i. Manpower : the number of R&D scientists are relatively small and experienced staff are even fewer. Highly qualified and mature researchers promoted up the management ladder are overburdened by administrative and managerial jobs. Hence, the R&D activities at the working level lack guidance and supervision.

ii. Hardware Facilities : research equipment is supported through the munificence of the government and foreign donors. Although the R&D facilities are improving in many government laboratories, the problem is of effective and efficient utilisation of these facilities as the capability of units to effectively operate and maintain the hardware is poor.

iii. Scientific and Technical Information : that state-of-the-art information relevant to research activities is not easy to obtain as the resources to procure basic standard S&T information are very limited.

iv. Management and Programmes : usual bureaucratic management of government is being practised in most R&D units. Flexibility needed to manage R&D activities is practically non-existent. Programmes are drawn up based on bottom-up plans, and the tendency is more towards 'what could be done' rather than 'what should be done'. Evaluation of programme activities is mostly for budget and spending purposes and lacks evaluation of the progress of the technical aspects.

v. Operational Funds : budgetary processes to support infrastructure and operational activities are very limited and as a consequence to cover the operational budget, funds are often drawn from a project budget.

(b) Factors related to motivation and creativity of manpower

i. Salary System : most of the R&D units are within the government system, and follow a civil servants salary system, which in general is not attractive and competitive for researchers and other professional staff. There are many R&D establishments outside the government system which offer better and more attractive remuneration. To overcome the situation, the government has introduced an incentive scheme in the form of a functional incentive. Since this compensation is relatively bigger than the basic salary system there is reluctance to carry out routine research. The incentive, created to promote better quality research work, has become an end in itself. There is another scheme by which to compensate for the lower salary system and is in the form of an honorarium given from project funds. This scheme created problems in effective coordination of resources.

ii. Career Planning : career progression of staff in R&D units is an important factor for motivation. However the duties, responsibilities, facilities and authority with the available positions in many cases are not clear and infact are rather ambiguous.

iii. Criteria for Successful Achievement : the criteria for achievement needs to be clear, rational and unambiguous and is needed for all levels of personnel within the research institutions.

iv. Communication and Information Exchange : communication and information exchange is essential for productive and creative team-work within research units. Sharing of knowledge, skills, facilities and data among the team members could help in the process of innovative thinking and action.

v. Accessibility to Research Facilities, Resources and Information : putting in place mechanisms that make researchers feel free and secure to utilise input resources to carry out their research program, is important for motivation and creativity. On the other hand, the mechanism should also accommodate within it,the needs for control and coordination at the level of the research units.

(c) Factors related to the environment external to R&D units

i. Cooperation among R&D units : cooperation amongst diverse R&D units contributes to development of innovative technology. However, in many cases it is not easy to implement this cooperation due to factors such as : organisation boundaries which tend to become bureaucratic barriers; competition to fund projects, as the sources for funds are common; heterogeneity in management systems and practices amongst R&D units; and facilities, skills and information being exploited as a source of income for/by the units.

ii. Conducive technology climate : the creation of a conducive climate for enhancing linkages amongst the constituents of the innovation chain, in developing countries, is a crucial role of government. The important factors that influence the performance of R&D community are : financial rules and regulations in R&D units; management systems for rewards and punishment; control and monitoring of research; effective equipment and hardware maintenance; policies to facilitate job turnover of professionals; and consistent and clear long and medium term plans and objectives.

Some development actions and concluding remarks

S&T has been assigned a pivotal role in the overall socio-economic development plan. Indigenous technological capability is to be increasingly utilised in national development projects. The government actively promotes productive linkages amongst the constituents in the innovation chain for technology transfer and enhancement of indigenous technological capability.

Actions required to be put in place to promote better linkages between enterprises and R&D community are :

(a) Related to enhancing technology demand : stimulation of industry to establish their own R&D units; tax incentive for investment on R&D; and establishment of strategic industries to promote technology transformation.

(b) Related to technology supply : one gate policy for research planning and funding by the government; incentives for collaborative research among R&D units; incentives for cooperative project between enterprises and R&D units; introduction of national appraisal for successful R&D projects; revitalisation of management systems to support S&T policy and planning; and promotion of peer-groups through more active professional association.

(c) Related to technology support facilities : development of S&T information networks; strengthening role of standardisation and quality control and assurance; exploring development of technology parks and incubators; promoting local consulting firms.

In summary, in order to promote the linkages amongst the constituents of innovation chain it is necessary to evolve/ develop a common platform where industry, R&D community, academia, administrators, and general public can voice their respective interests and strike mutually beneficial partnerships and cooperation. Indonesia, is still in the learning process and is yet to evolve the most appropriate system and mechanism. This is not an easy task, but exchange of experiences and knowledge amongst countries through international or regional workshops and seminars could facilitate the learning process.

Policy Incentives for Commercialisation of R&D Outputs

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Introduction

Technology plays an important role in the general development of a country's economy and the technology factor must be enhanced to achieve a sustained and stable growth. Technological progress must always be viewed as being related to the path of economic growth which in tum is dictated by the nation's economic policy, and by direct and indirect government intervention. These objectives can be achieved by applying tax incentives, financing tools, restrictive measures, preferential government procurement, development of Science and Technology infrastructure and R&D programs and support for technology imports. Among the support mechanisms most closely associated with govemment policy are financing tools and the effectiveness of these is key to inducing the appropriate development of technology in a country.

Development Policy Financing (DPF) is a financing program executed and intervened by the government or a government-controlled financial institution to channel resources in order to supplement the mechanism of commercial financing or to promote certain areas or industrial sectors to comply with a country's economic strategy. The principal purpose of DPF is to make up for a credit gap, caused by factors that adversely affect capital flow to certain economic sectors. DPF has been adopted by most countries during various stages of development and the degree to which it is employed depends on the economic structure, management policies or systems. This paper focuses on aspects of DPF that contribute to enhancing the technological competence of a nation.

Technology development financing

Technology Development Financing (TDF) is the best form of development financing. It allows the targeted industrial sector, or technology oriented industries, to easily access available and favourable financing through financial institutions for technology development. TDF entails a high risk factor, considering the investment return and success in the market. If private investment activities are left on their path, there is a strong possibility that the industrial and financial trends would avoid the risk and much of the flow of financial resources would be channelled into other sectors where returns on investment were better ensured. Despite this, technology development must still be regarded as an important area for sound and healthy industrial progress. In most cases, industrial firms face difficulty in raising funds for the intangible inputs of knowledge and expertise, or the "software" aspect of technology development from existing financial institutions. To understand this situation, it is important to consider the innovation cycle which consists of four phases: start-up, pre-commercial, expansion and maturity. The first phase, start-up, comprises feasibility studies and technical research. The second phase, pre-commercial, involves construction of prototypes and pilot plants, preliminary production and marketing tests. The third phase, expansion, consists of rapid expansion of production and sales. In the fourth phase, maturity, sales grow nominally in accordance with the state of the economy and market conditions.

Traditionally, the focus of industrial development has been on the market phase of the technological innovation process. This may be appropriate for a developing country that relied on imported, already proven, standard technologies embodied in machineries and equipments, which could be easily assimilated. Commercial banks and other conventional financing institutions provide the financing services useful at the expansion and maturity phase of the innovation cycle. However, these services are not available at the start-up and pre-commercial phases, namely the pre-market phases.

Universities and public R&D institutes are responsible for research, development and some of the engineering phase of the technology innovation cycle while large companies and small and medium industries (SMIs) are responsible for the start-up and the volume production of the technology innovation cycle. The risk factor reduces as it moves from research to the mass production stage.

Technology development in Korean industry and government's role

Korea is regarded as one of the most successfully industrialised countries in the developing world. This success is due not only to the significant economic growth propelled by unprecedented industrial expansion, but is also due to the diversification of its industrial structure into certain technology-intensive areas in a short period of time. A series of five year economic development plan that began in 1962, emphasised rapid industrialisation, technology and manpower development, and increased Korea's stake in the international market through export expansion. Science and technology policy since the very beginning has given emphasis to strengthening scientific and technical education, build-up of technological infrastructure, and promoting foreign technology imports.

Korea opted for a significant policy change in the 1970s, when it shifted towards heavy and chemical industries, technological and skilled labour intensive industries. The government contracted investments in capital-intensive industries and moved some of the resources to technology-intensive industries, such as microelectronics and telecommunications. The programs then financed by both government and industry, focused on developing strategic, high-risk, high-cost technologies, which could not be developed by industry alone. Some examples of projects commercialised by these research programs include the development of the 4M DRAM, the localisation of fuel supply for nuclear reactors and the development of artificial diamonds.

Industrial R&D development was also encouraged through a system of government policies and incentives such as the subsidisation of development costs, subsidisation of prototype manufacturing, favourable tax incentive schemes, investment and loan financing, promotion of venture capital, easing of licensing requirements, intellectual property policies and easing of restrictions of technology transfer.

The contribution of private R&D investment has been rising over the years. Government-to-private investment ratios have changed from 97:3 in 1963 to 20:80 in 1993 as shown in the Table 1.

Table 1: Trends in R&D Financing (US$ million)

	1980	1988	1993
TOTAL	480	3068	7541
Gov't	325	653	1455
Private	155	2414	6086
Total as % of GNP	0.68	1.94	2.4
Ratio : Gov't/Pvt.	68/32	21/79	19/81

In general, the arena of R&D policy, as opposed to financial policy, has developed rapidly since the early 1980s through actions such as the formation of the Technology Promotion Council and the subsequent establishment of national technology goals. With these developments, Korea successfully created the technology environment prevalent in most industrialised democracies where there existed substantial market and development influences that affected the technology development processes in corporations.

Government's commercialisation strategies in the field of vertically linked cooperative research and development

The Korean Government in the 1980s initiated the cooperative R&D strategy between government-sponsored research institutes (GRIs) and privately owned industries. The major concern of the participant firms in vertical cooperative R&D with GRIs was acquiring technological capability, whereas horizontal cooperative R&D sought access to certain markets with combined efforts.

Cooperative R&D between private firms and GRIs is classified as vertical cooperative R&D in that there is an implicitly assumed division of labour in two sectors of the society. Consequently, new technologies were acquired by private firms' in collaboration with GRIs. Today however, GRIs-industry collaboration in Korea still goes on only in large-scale frontier technology development programs such as the Highly Advanced National (HAN) R&D Program.

Studies on cooperative R&D have emphasised the supplementary role of additional technology acquisition strategies for commercial utilisation of the results of cooperative R&D. Cooperative R&D might lower the risk and aid the rapid commercialisation or development of many technologies, but cooperative R&D alone is insufficient for commercial success or the realisation of an economic payoff. A mixed strategy i.e. external sourcing of technology followed by substantial and sustained internal adaptation and improvement, needs to be applied for commercial utilisation of externally acquired technologies (including cooperative R&D).

Some duplication of in-house R&D investments of firms is inevitable even when these firms participate in cooperative R&D. Firms in Korea thus acquired technologies available from external sources through purchase or licensing-in as well as using in-house R&D to supplement cooperative R&D with GRIs. Korea's strategic emphasis on technology sourcing has recently shifted from licensing to internal R&D. Most of Korean industries are at the internalization stage rather than the generation stage. Thus, they prefer licensing and still rely on external sources of technology in addition to internal R&D. Without enough intrafirm technological capabilities, they cannot rely on in-house R&D to supplement commercial utilisation of cooperative R&D results. Instead, they rely on licensing-in or purchasing external technologies available from developed countries. Some firms participate in cooperative R&D projects to enhance their bargaining power in purchase or licensing-in foreign technologies. However, by the end of 1980s, boosting the international competitiveness of Korean firms through technological innovation and product differentiation was a national priority.

Venture capital industry in Korea

The venture capital industry has been identified as a viable means of financing technology based companies and to further the involvement of foreign firms in Korea. The government is heavily involved in the venture capital industry in Korea. The Ministry of Science & Technology launched the Center for Research and Development Commercialisation (CRDC) whose role is to promote the transfer and commercialisation of new technologies from universities and GRIs to private industry. One critical function of the CRDC is to provide the long term loans to support the private firm's commercialisation process as well as the consolidation of marketing activities in the field of technology based venture business. The Korean government has provided up to 80-90 per cent of the total R&D investment of the R&D institutes which were involved in national R&D projects for core and fundamental technology development, industrial technology, alternative energy technology development and other programmes formulated by the government. Also, the government has provided financial support of up to 50 per cent of total cost to individuals or small firms for commercialising new technology.

In 1981, the Korea Technology Development Corporation (KTDC) was established by the Government as a private entity with partial government participation in its equity. In fact, it was the first technology development financing institution incorporated under a special law, the Korea Technology Development Corporation Act. At the beginning, KTDC enjoyed direct financial support from the government in the form of equity participation, the provision of guarantees for borrowings as well as direct borrowings from the government.

But in May 1986, the Small and Medium Enterprise Start-up Support Act (SMESS Act) was legislated by the Ministry of Trade and Industry to support the establishment and growth of small enterprises, and to assist venture capital companies. Therefore, new venture capital firms began forming under the SMESS Act and the use of venture capital grew rapidly. As a result, in July 1992, the government deregulated a number of restrictions imposed on SMESS Act venture capital companies in order to revitalise the industry. This included the expansion of investment scope, the removal of the restriction on investment in companies older than five years, and the authorisation to use loans as a means of financing.

The government has ceased to offer additional direct borrowings since 1989. Instead, the government has authorised KTDC to start a factoring and leasing service. The government gradually reduced its support in order to enable KTDC to run as an autonomous operation during the period 1986 to 1989. In 1992, the Korea Technology Banking Corporation Act allowed KTDC to transfer its name and function to Korea Technology Banking (KTB) which offered comprehensive financial support to private companies involved in technology development activities.

Conclusion

In the last three decades, the Korean economy and industry has grown rapidly. At the initial stages, the government was not in a position to raise large funds for R&D or technology development financing (TDF) that were needed to support the venture capital industry in relation to the commercialization of R&D outputs. However, government took a bold initiative to create an R&D infrastructure to facilitate technology transfer, and later to carry out indigenous R&D activities. Korea's long-term objective is to equip the country's industrial sector with sizeable technological and innovative capacity in order to compensate for its rapidly disappearing comparative advantage in labour-intensive industries. Hence, the development strategy pursued includes: reinforcing graduate school education; expanding overseas training for scientists; repatriating experts from abroad; encouraging research institutions, universities, and industries to conduct joint R&D; providing assistance to firms that conduct in-house R&D; and above all extending financial support to industrial technological development.

Structure & Organisation of S&T and R&D In Nepal

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Introduction

Science and Technology (S&T) in Nepal has played an important role in socio-economic development and in building indigenous technology capability. However the history of modern science and technology in Nepal is not long. The first Five Year Plan in 1956 started with a virtually zero level of S&T infrastructure base. The country has since then been striving hard to build up S&T capabilities by creating and improving infrastructure facilities and developing S&T manpower. Nepal being a mountainous country the transport and communication network is a very critical element in the overall development of the nation. And therefore this sector has been accorded budget priority in the four successive Five Year Plans followed in priority by agriculture, industry and education.

Although the new national education system introduced in 1971 could not be completely implemented due to various reasons, however, the system has for the first time emphasised on the expansion and improvement of S&T education and also created research and development (R&D) activities as an important element of S&T education. The Tribhuvan University (T.U.) has established various institutes of higher learning viz. Institute of Agriculture and Animal Science (IAAS), Institute of Medicine (IOM), Institute of Forestry (IOF), Institute of Engineering (IOE), and Institute of Science and Technology (IOST). A significant shift in the building up of S&T infrastructure has been the establishment of various laboratories in government departments to support their respective R&D activities. The major areas where government R&D institutions are involved include agriculture, forestry, medicine, meteorology, hydrology, irrigation and plant resource utilisation. An integrated national S&T programme with the basic objective of economic development of the country has been recognized at the policy level only from the fifth Five Year Plan (1975-80). The constitution of National Council for Science and Technology (NCST) as an advisory body to His Majesty's Government in 1976 made it possible to make preliminary efforts towards the formulation of national S&T

policies and programmes. In 1977, the Research Centre for Applied Science and Technology (RECAST) was established under T.U. entirely devoted to R&D activities. With the objective of further development and promotion of S&T, the Royal Nepal Academy of Science and Technology (RONAST) was founded in 1982.

R&D infrastructure

Most government and university have laboratories in Nepal the basic necessary physical infrastructure and some of them are very well equipped. However, skilled manpower and research environment is lacking in these laboratories. During the last two decades, S&T in Nepal has changed with the emergence of semi-government and non-government S&T institutions, with T.U. being the first among such institutions. NGOs and private R&D institutions are slowly increasing, and the Agriculture Research Council (NARC) is striving to lead to the institutionalisation of an autonomous client oriented and cost effective agriculture research system in Nepal.

Investment in R&D

Investment in R&D is inadequate as Nepal has been spending only about 0.13 per cent of its GNP on R&D activities which is the lowest figure even in the SAARC (South Asian Association for Regional Cooperation) countries. Realising the importance of the role of S&T in the sustainable development of the nation the government has accorded it an important place in the Eighth Five Year Plan.

Information and documentation services

Most institutions (public and private) have their own libraries and documentation centers aimed primarily at fulfilling the needs of S&T information and documentation services of their respective organisations. T.U. Central Library, Kathmandu is the largest organised library in Nepal, with several hundred thousand volumes of books and journals. National Agricultural Documentation Centres under NARC and IAAS have the large collections of agriculture related books and journals. A good collection of S&T information, including books and journals was also available in organisations like RECAST, IOE, IOF, IOM, Economic Service Centre and Departments of HMG.

R&D manpower

The availability of knowledgeable staff for R&D activities is critical to the successful performance of R&D organisations. Earlier Nepal depended on foreign countries for higher education in S&T and foreign experts, but now the scenario is changing. The higher level S&T manpower employed in Nepal was 2377 in 1977 whereas it has reached 8190 in 1992 as per a field survey made by NCST.

Basic issues and problems

Certain basic issues require immediate attention in Nepal. There is no explicit S&T policy in Nepal. Even in the eighth Five Year Plan, S&T policy had been placed only as a component of national development policies. S&T activities are not of much concern to political leaders under the prevailing conditions, R&D results cannot be effectively utilised. Activities such as coordination, budgeting and management of S&T are missing in the present S&T policy. R&D investment should be made mainly for research oriented activities appropriate in the national context and preference should be given to time bound and mission oriented programmes. Coordination and linkage among R&D organisations and user agencies is not satisfactory in Nepal.

Facilitation and promotion of inter communicating abilities among private agencies, research institutions, professional societies and technology users is very important in order to create a conducive environment to promote and develop S&T in any developing country like Nepal.

Factors Influencing Performance of an R&D Organisation: The Case of C.S.I.R, India

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Introduction

CSIR (Council of Scientific and Industrial Research) is a network of 40 laboratories spread all over India with a total staff of around 25,000 of which 6000 are highly qualified scientists; the annual expenditure is around Rs. 3,900 million, of which around 25 per cent is derived from outside the government grant. CSIR's output is reflected by around 250 Indian patents and 15 foreign patents filled annually and 2,600 scientific papers contributed; 50 new technologies developed in a year and 200 licence agreements executed. On an average CSIR has in hand 1100 R&D contracts worth Rs. 1700 million and 650 consultancy projects worth Rs. 200 million every year. CSIR developed technologies are creating additional production of around Rs. 800 million per year and contributing to productivity improvements worth Rs. 200 million annually. With these credentials CSIR seems to be a good example whose experience could be shared by the countries of the region.

External factors

The performance of R&D is dependent on factors external as well internal to an organisation. The external factors are demand for S&T, government policies influencing S&T and supporting infrastructure available in the country. On the other hand strategic planning, operational aspects and human resources management are factors inherent to the organisation that effect its performance. The demand for S&T is reflected in various forms: domestic S&T demand manifests itself indirectly by the overall national R&D expenditures as well by the R&D expenditures incurred by different sources such as government, industry etc., and in the various economic/ social sectors. In industry the size of firms, their profitability levels and R&D expenditures, and record of precompetitive R&D carries out indicates the demand for S&T. The international demand for S&T, that influences domestic R&D is indicated by international R&D contracts, secured and catalysed - this depends on the quality and cost competitiveness of domestic R&D as also the domestic government policies with respect to IPR, and procedural facilities. It is also a pre-requisite for international R&D contracts that the IPR regime and the judicial system and policies of the country were seen to be fair, just and equitable. To secure R&D business from abroad an effective communication system and an understanding of the culture of the other country are the other necessary parameters. The demand for S&T in India is low, as R&D expenditure is only around 0.85 per cent of GNP; overall R&D expenditure by industry is only 25 per cent of the total; and the size of industrial units is small and sub-optimal; there is no track record of cooperative R&D; and, above all there is a weak R&D-industry-government interaction and linkage. While R&D expenditure in leading industrialised countries like USA, Japan and Korea has been increasing in recent times as a percentage of GNP in India, though R&D expenditure in absolute terms has shown a slight increase, as a percentage of GNP it had declined from 1 per cent in 1987 to 0.85 per cent in 1992. Around 25 per cent of the national R&D expenditure was contributed by industry whereas in countries like USA it was 50 per cent , UK 60 per cent and Germany, Japan and Korea much higher. At the individual firm level the national Indian average of R&D expenditure was only 0.7 per cent of sales; even the largest of Indian companies like BHEL and SAIL spend around 1.5 per cent of their sales on R&D, as compared to similar firms abroad who spent in excess of 7 per cent on R&D. These factors combined with lack of cooperative R&D and weak industry-R&D interaction has led to low or negligible demand for S&T in the country.

Among the other external factors that have a bearing on the performance of an R&D organisation are government policies relating to science & technology and its role in economic planning; especially those for encouraging/ promoting R&D-industry-government interaction, trade policies, taxation and fiscal policies. The missing links between government, R&D institutes and the industry or users in most developing countries are the absence of incentives or pressures by government that motivate and make it worthwhile for industry to undertake R&D. Governments in these countries seldom or rarely identify or lay down national priorities which can then be converted into viable R&D projects by the indigenous R&D system. On the other hand the R&D projects in S&T institutes in these countries by and large are not aligned with national priorities even in rare cases where these are explicitly defined or laid down. Also, the R&D institutes are busy developing technologies which in their opinion are needed by industry ignoring the actual needs of industry and are thus working in isolation of the market. Industry in a developing country hardly has the time, will or resources to carry out R&D as also to recognise and accord a proper role to technology in the overall corporate strategy with the result that there is hardly any demand for S&T.

The performance of an R&D organisation is to a large extent influenced by the supporting and enabling infrastructure. Thus it is essential that there is easy information access to what was happening worldwide in S&T and their areas of activities, and a sympathetic IPR regime is essential for an indigenous R&D system to thrive. Further, engineering & design organisations are essential to translate the technology generated by R&D and make it suitable for industry and other users of the R&D outputs. An indigenous capability in fabrication of equipment is definitely helpful in commercialisation of R&D. For successful technology transfer, the role of technology licensors and brokers is in no way insignificant. Commercialisation of technologies developed by R&D institutions involve financial risks and entrepreneurs / industry are generally reluctant to invest in such projects. It is thus essential that venture and risk capital funds are created to support exploitation of domestic technologies.

Since these external factors significantly affect the performance of an R&D organisation, initiatives are needed at all levels of government and industry to create an environment conducive to development and use of indigenous R&D.

Internal factors

It is essential that R&D organisations involve specific R&D strategies/plans to improve effectiveness. The essential components of such a strategic plan could be alignment of corporate objectives with national priorities and market needs, formulation of an appropriate basket of projects, prioritisation of R&D projects, optimal resource allocation in terms of manpower and funds and formation of cross functional teams. CSIR is a good example of this route to success. Recognising the changing global economic and technological scenario, CSIR reoriented its corporate objectives and thus initiated programmes/ activities to meet the challenges and avail of the opportunities so created. CSIR restructured its resource deployment so as to become more user oriented; CSIR was earlier spending around 35 per cent of its R&D on basic research and 25 per cent on industry and economy oriented projects (the balance 40 per cent was made up by societal welfare programmes and S&T support services). This pattern has changed; for VIII Plan period (1992-1997) the industry and economy sector has been allocated a -45 per cent of the budget and the share of basic research has been reduced to 20 per cent but this is still considerable since it is recognised that for competitive industrial R&D basic R&D is essential. In order to optimise returns on investment, CSIR opted for a project mix of short term projects of around 50 per cent to yield returns, within three years and long and medium term projects - 25 per cent each. Technology becoming more and more complex and it is increasingly necessary to form synergistic alliances to tackle its many diverse aspects. CSIR is a network of multidisciplinary laboratories and thus plans to harness the strengths and infrastructure available in different laboratories within and outside the CSIR system depending on the need. It is however not enough to merely evolve a plan; certain operational aspects need consideration as well, and necessary mechanisms are required to be put in place to implement the plan. The basic aspects that need to be taken care of are clear definition of project scope and objectives, multifunctional inputs in project formulation, effective communication - interfunctional as well as interpersonal, operational flexibility, effective monitoring of projects in terms of time, cost and quality, operational support and last but not least, effective publicity and marketing. The various operational reforms carried out by CSIR include improved project management systems comprising project formulation based on technology and demand forecast and greater involvement of users. The projects are monitored by headquarters and the research councils of the laboratory and Technical Advisory Boards (TABs) (in five economic sectors) having memberships of academia, industry and government departments/ agencies etc. Further the decision making has been decentralised at the operational level with emphasis on responsibilities and accountability. Marketing has been recognised as the basic requirement for effective utilisation of an R&D knowledge base and thus business development and marketing activity has been made a distinct integral activity of R&D in CSIR. In order to encourage generation of revenues, an incentives and recognition system has been recently instituted for the staff.

Human resource management

Human resource management is inherent to an organisation and constitutes an essential component of the efforts to improve performance of the organisation. The various aspects in this are recruitment policy, recognition and rewards, career development avenues, harmonising of individual and corporate goals, training/ retraining/ redeployment, encouraging development of cross functional expertise, multichannel development options and an effective and humane grievance containment and redressal system. Some of the initiatives taken by CSIR include career advancement linked to performance/ merit, monetary incentives for taking/catalysing commercial R&D such as sharing with staff the monies received from marketing of knowledge base, recognition for securing IPRs abroad and training abroad for young scientists.

Conclusion

There are many factors responsible for lower utilisation of technology developed in indigenous R&D systems in developing countries as against technologies from industrialised countries. The technologies from R&D laboratories in developing countries suffer from the drawback that these are not commercially proven. Also the development in a majority of the cases comprises only laboratory scale process knowhow or product design, with the engineering component being either inadequate or totally absent with the result that the client has to put together different elements of a technology package leading to numerous problems in upscaling and commercialisation. There is no licensors' brand name/ goodwill involved. Further, such technologies involve high technology and financial risks and financial institutions largely disfavoured to supporting ventures based on these technologies. On the other hand foreign technologies are commercially proven and complete technology packages are available. The technology also carries a brandname and licensor goodwill. Thus these technologies involve low technological risks and find favour with financial institutions. Unless indigenous technologies are brought up to these levels, their utilisation will continue to suffer. Since problems, experiences and ethos of R&D institutions in developing countries are similar, a regional association of such institutions could provide a forum for discussing and debating the hurdles and the ways, means, policies and strategies to overcome them. The suggested acronym for the association is RACORD (Regional Association for Communication of R&D).

Special Aspects and Issues Concerning Application or Commercialisation of R&D Results in Selected Areas

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Introduction

Commercialisation/application of R&D results involves interfacing between different components of the innovation chain, viz., R&D institutions, technical consultancy organisations, financial institutions and entrepreneurs. The meaning and content of R&D for each of these agencies is different and it was this that determines their approach and treatment towards the application/ utilisation of R&D. A proper synthesis of the different approaches is needed for successful utilisation of the R&D outputs.

The purpose of R&D can be explained with the help of the 'S' curve which represents three distinct stages of R&D, viz., invention, innovation and diffusion. In any technology development, initially the development comprises basic research resulting in invention and its utilisation is in terms of research papers, patents etc, and academic institutions/ universities are active at this stage. The next stage of R&D is innovation where the invention with appropriate engineering and consultancy inputs is transformed into an innovation. The commercialisation of R&D generally takes place at the diffusion stage where the additional inputs to convert innovation into commercialisable technologies needed are finance and enterprise. At the diffusion stage the technology reaches maturity and incremental R&D is needed to improve productivity and create product differentiation. Japan and Korea have very strong bases that carry out incremental R&D to achieve increased production and product differentiation.

Commercialisation of technology

For commercialisation of R&D outputs, a combination and or presence of certain parameters is essential. In its simplest form a production technology is a method of combining the five Ms :

M1 : Machine / Knowhow
M2 : Materials / Energy
M3 : Manpower / Management
M4 : Money
M5 : Market

Traditional technologies used simple tools (M1), locally available materials (M2), minimum investments (M3), family unit for management and manpower (M4) and small surrounding markets (M5). Available industrial technologies are based on large M1, M2, M3 and M4 procured from different locations to produce standard goods fpr M5. Machine or knowhow i.e., M1 in itself does not specify the technology. In fact M2, M3 and M4 decide the type of machinery or knowhow that can produce M5 i.e., meet the user or market demand. The main limitation of conventional technologies in use is that, in the absence of detailed knowledge of materials (M2) and knowhow (M1), only a limited type of combinations of Ms i.e., technologies are tried. Developments in informatics, biology and material sciences have improved understanding of process knowhow i.e. M1 and the materials (M2) many-fold for example, microprocessors enabled making of machinery that is flexible, and modern biology has given a variety of new bio-chemical processes. This knowledge, is then used for combining Ms in new ways. Thus, new combinations or new technologies could be developed to give production processes. Mere attainment of R&D results cannot essentially lead to commercialisation; synchronisation of these five Ms is essential for commercialisation at the time of technology transfer package. If the technology transfer package takes care of at least four Ms, the chances of commercialisation of technology are greater. Any management sensitive to the five Ms is a successful management. In CSIR, some laboratories have started paying attention to this and are trying to build up capabilities to package these Ms with the help of outside consultancy firms towards achieving better utilisation of their R&D outputs.

Conclusion

The direction of modernisation of technology is towards meeting the diverse requirements of individuals; from 'mass production' of uniform goods and services to those custom tailored to meet the needs of individuals. Flexible automation is a revolutionary response to the complexity-reliability-variety barrier. The Flexible Manufacturing System offers custom tailored manufacturing combining maximum flexibility in manufacturing operation though with lower efficiency of production. The mass production system on the other hand has maximum efficiency of production but offers less flexibility in manufacturing operations and thus often overlooks customers specific needs. Batch production is somewhere between the two, both in terms of flexibility and efficiency of production. Not only are the final technological products but also the manufacturing process itself is undergoing a change. There have been significant paradigm shifts in the manufacturing processes/components of technology in recent years.

R&D Community - Enterprise Cooperation

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Introduction

The present limitations facing the R&D sector in Pakistan include a large proliferation of R&D public funded institutes in the country; there were over 400 public sector R&D institutes of which at least 150 are in the area of applied R&D. However the commercialisation of R&D results is poor and the revenues earned by these institutes is negligible. Also the only source for funds is government grants to these institutes which is inadequate with the result that R&D efforts are sub-optimal.

The reasons for these limitations are poor private sector interest in R&D and public sector R&D being mostly supply driven and having bureaucratic structures providing no flexibility in functioning of the institutes. There are no pilot plant facilities for upscaling and evaluation of technologies. Besides, there is hardly any motivation and incentive for the scientists/ staff of these institutes. These institutes also have weak marketing systems.

Technology policy

The future outlook/ direction for R&D in Pakistan has been outlined in the new technology policy of the country. The government of Pakistan desires indigenous R&D to play a major role in national development and make industry globally competitive. With this in view, the Government has set certain goals for indigenous R&D systems. The short term goals comprises (a) increased utilisation of indigenous research and (b) reduced dependence of R&D institutes on Government grants and the long term goals comprises (a) increased/improved public-private sector involvement in R&D and (b) increased research through private sector industries. The government of Pakistan is seeking collaboration with the World Bank and has allocated considerable resources for a technology development plan. The specific strategies for greater commercialisation of R&D envisage :

i. allocating a leading role for the private sector in R&D;

ii. instituting financial incentives for private sector investment;

iii. rationalisating of the R&D system by way of multidisciplinary collaboration, reorganisation of public sector R&D and allocation of 2 per cent of GNP to R&D by 2000;

iv. enhancing commercialisation of R&D by making it market driven and adopting aggressive marketing;

v. generating revenue through public borrowings;

vi. enhancing utilisation of R&D results for R&D in public/ private sector through financial support from venture capital companies;

vii. building endogenous R&D capacity in firms.

Conclusion

Some suggestions towards regional cooperation:

i. establish a $ 10 million seed money revolving fund probably by APCTT to support indigenous technology development effort;

ii. establish linkages between R&D institutes of the region to avoid duplication of R&D efforts;

iii. undertake joint research projects especially in new and emerging areas;

iv. evolve bi/multi literal exchange programmes for scientists, technologists and marketers in institutes of the region;

v. organise 'focused' workshop by APCTT on issues/subjects related to a greater R&D Community - Enterprises Cooperation.

Considerations Regarding the Evolution and Impact of Biotechnologies with Particular Reference to Developing Countries

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Introduction

Biotechnologies(BT) are playing an increasingly important role in the growth and trade of developing countries. BTs have introduced new methods such as improving plant and animal varieties, modifying micro-organisms responding to desirable characteristics, changing the nature of products, etc. The major applications of BT are thus in the areas of food production and pharmaceuticals and other areas of application include energy, new materials and waste treatment. While this has opened up new opportunities and possibilities for countries actively using these technologies, it also represents a threat to established products and markets, many of which already exist in the developing countries. Thus developing countries in particular could face the situation of losing export markets once biotechnological substances substitute natural products or raw materials on a large scale.

The first entrants in this emerging industry were the small high-tech enterprises established by scientists themselves and financed through venture capital. Large enterprises moved into the field of biotechnology with some delay. Also the commercialisation and market introduction of biotechnological products have taken considerably longer than initially projected and it was only at the beginning of the 1990s that biotechnological products increasingly reached the market.

Economic aspects and implications of biotechnology

New biotechnologies are still the domain of highly industrialised countries, both with regard to capability for R&D investments and their exploitation potential and the developing countries are at the receiving end with regard to BT transfer and trade flows. Some of the recent BT developments in the United States, Europe and Japan have implications for developing countries. Some areas of application are :

Food products

Fermented food represents huge markets in which BT is making significant impact. A well-known development is the introduction of high fructose corn syrup obtained from maize and other sweeteners, substituting for sucrose made from sugar cane and sugar beet, grown mostly by developing countries. Both sucrose and fructose are currently being challenged by non-sugar sweeteners. This affects agro-industrial production and exports of quite a number of developing countries, particularly those who rely on sugar cane exports. Besides, improved additives, preservatives, flavourings colouring stabilisers, enzymes, etc. are being increasingly manufactured using BTs instead of chemical synthesis.

Agriculture

The recent developments in this area relate to development of hybrid seeds/crops giving higher yields and offering increased resistance to cold and draught, diseases and insects, parasites and herbicides, better nitrogen fixation, and resistance to soil salinity. The production of transgenic animals or the development of benign microorganisms are the potential technological options for the future. Several such innovations are already being applied in developed countries and some developing countries.

Chemicals and pharmaceuticals

Several chemicals such as methanol, ethanol or complex alcohols can now be produced by fermentation of biomass or waste products. The development of immobilisation techniques and of enzymatic engineering have made it possible to produce highly specialised enzymes, microbial agents and biocatalysts and convert wastes into biofertilisers etc. Biological leaching methods are replacing mechanical and chemical methods of beneficiation/ separation of minerals. Some of these developments have the potential to replace capital intensive manufacturing of these products and thus offer advantages to developing countries.

In the area of pharmaceuticals, the use of BT has been extensive and a rapidly growing number of pharmaceuticals encompassing antibiotics, vitamins, insulin, cell cultures for vaccine, etc. are being produced by applications of BT.

Reagents, equipment and bioelectronics

BTs such as biosensors as well as automatic cell sorters are already on the market, and efforts are now being made to isolate organic biological molecules which may be used for information processing and artificial intelligence in automated processes, computer assisted design and engineering, in instruments such as pacemakers, artificial limbs or even solar energy conversion.

Prospects for BT and its possible impact

While BTs are making significant progress and contributing to economic development, they have given rise to a number of issues and concerns. The safety issue is at the forefront of thinking among the OECD countries, and has led to the formulation in 1986 of safety guidelines intended primarily to avoid spreading of harmful micro-organisms created in the laboratories. A more global code of conduct for the release of organisms into the environment has been worked out by the United Nations Industrial Development Organisation (UNIDO). Quality certifications concerning food, drinks, pharmaceuticals etc. are also being evolved in order to ensure suitable standards and avoid undesirable side effects for the consumer. Other issues of concern are the ethics of genetic engineering, which could entail abuses as regards the genetically-engineered determination of individual characteristics, the issue of patents etc.Notwithstanding the above issues, BTs have a widening spectrum of commercial applications replacing the traditional manufacturing technologies besides opening up new opportunities and markets. Some of the significant outcomes of BT include:

(a) Preparing human grade insulin through BT displacing more costly modes of production;

(b) Adapting plants and animals through genetic engineering to substantially different kinds of relatively hostile environments which could lead to increased use of arid or saline soils for agricultural purposes especially in developing countries;

(c) Bioleaching of ores;

(d) Use of recombinant DNA (rDNA) technologies for plants to fix nitrogen more efficiently.

It is, however, illusory to think that any one country can carry out research on the whole spectrum of opportunities offered by BT. It would be useful to concentrate on fewer areas e.g. plant and animals to meet food needs, or on biotechnologies to ameliorate the efficiency and the levels of production in difficult ecological zones such as arid lands.

Biotechnology strategic alliances : models for cooperation

In most of the industrialised countries, the BT industry has formed cooperative relationships/alliances for research, with university institutions or among otherwise competing enterprises themselves. When new biotechnological companies were established in the 1970s, the common feature was their proximity to universities and research laboratories and in many cases researchers transformed themselves into entrepreneurs or became advisors and shareholders in these firms. However, a few years later larger corporations developed interest in this field and cooperation alliances with universities, national laboratories etc. were formed. In the United States, the Federal Technology Transfer Act of 1986 established a new era in industry-government cooperation in research by officially authorising closer working ties between government laboratories and industry in the area of R&D. These alliances took a variety of shapes such as:

(a) Long-term multi-project partnerships that pool research prodûction, and marketing of different companies within a country or across countries as non-equity joint ventures to accomplish strategic goals;

(b) Joint ventures between different companies to create a new product or service;

(c) Multi-company research consortia at the pre-competitive level involving technology cross-licensing and reciprocal marketing activities; and

(d) Mergers and acquisitions in high growth sectors and between high potential firms[1].

Parallel to these alliances at the company level, there was an expansion of enabling institutions such as venture capital funds, incubators for start-up companies, public research consortia that actively promoted or facilitated inter-firm or inter-organisational linkages. Biodiversity within many developing countries provide large stocks of untapped genetic resources to be utilised in are such as agricultural development or pharmaceuticals. Using the alliance model by establishing enabling institutions, policies and incentives and forming worldwide partnerships could be one step to develop local R&D in BT which could be linked to the commercialisation of its products at an early stage.

Biotechnology for small enterprises in developing countries

One of the advantages of BT is that many production systems do not necessarily require large-scale technological investment which is a prerequisite in other sectors involving new technologies. Within a longer term perspective, BT promises to address two of the major challenges faced by developing countries, i.e. meeting basic needs in the area of food and of materialising some of the opportunities arising from the international trade liberalisation process. Also while biotechnology is likely to substitute some traditional export products of developing countries, it could also lead to the development of new agricultural or pharmaceutical products. Thus, biodiversity in many developing countries provides a stock of untapped genetic resources that could be utilised in agriculture for plants, fertilisers, etc.

Notwithstanding all these developments there are still considerable obstacles to successful commercialisation of results in BT by developing countries. To benefit small and medium enterprises this requires changes in the research agenda, for example:

(a) Re-orienting the technologies' focus from resource-rich producers and large-scale urban industries to the practical problems of developing countries and small-scale production;

(b) Translating results of research to practical applications and commercialisation requiring long-term, strong R&D efforts as well as acceptability by target populations.

Thus, successful R&D alone is not sufficient; consultation with client groups in the development process and an assessment of local needs and of the potential impact of technological innovation are essential elements of any new technological development and its integration into the national economic strategy. Networking, alliances and participation of user groups are some of the effective ways of addressing these problems.

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Issues Concerning Commercialisation of R&D Results

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Introduction

The objectives of the Central Glass & Ceramic Research Institute (CGCRI) are multiple and its activities encompass material research and development to fulfill the country's domestic market and defence requirements. The laboratory has been reorienting its goals/ objectives with the changing demand pattem of Society. A number of R&D projects have been taken up with a view to catch up with the industrialised countries and amongst them are microelectronic ceramics, electroceramics, optical communication fibre, non-oxide ceramics etc. While undertaking development of a particular technology, emphasis was placed on utilisation of indigenous raw materials to the maximum extent. CGCRI has developed technologies that utilise wastes from industry, agriculture etc.

Products from wastes

Technologies have been developed to convert waste phosphogypsum from the fertiliser industry and to utilise beach sand. The former has been used along with glass fibre to make Glass Reinforced Gypsum (GRG) boards. This technology is especially suitable for countries which do not possess selenite gypsum. The GRG Boards are a timber substitute and can be made of thicknesses of 6 mm upwards for door panels, partitions; false ceilings, furniture etc. The technology developed comprises two stages i.e. conversion of phosphogypsum into plaster of Paris and its further conversion to GRG boards. The plaster of Paris made by this process is 25 per cent cheaper than that made from selenite plaster and the GRG boards made are 50 per cent cheaper than teakwood and 25 per cent cheaper than common wood.

The technology has been developed on a pilot plant scale and that the transfer of technology is satisfactory is evident from the fact that a few parties have commenced commercial production of these boards.

The other technology developed is to make synthetic granite from Indian beach sand garnet. The beach sand is mixed with additives and fillers and then ground in a ball mill. The resulting mass is pressed into different shapes for applications as tiles, blocks, cubes etc. and then sintered to obtain ready to use product. These tiles can be used as floor polishing stone, synthetic granite tiles, abrasion resistant tiles etc. Besides this, other technologies developed use wastes such as fly ash, coal ash (cinder) with clay to make floor and wall tiles, and crockery/ sanitaryware.

Conclusion

The laboratory carries out economic viability studies for the technologies developed by it. The development work in most cases is carried out to an adequate level from where transfer of technology to a commercial level generally does not cause any major problems.

Building Materials : Technology Development and Transfer

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R&D programmes at CBRI

After food and clothing, shelter is the next important aspect in man's life. There is an acute shortage of housing in India, presently estimated at 25 million dwelling units in rural and urban sectors which is expected to rise to 40 million numbers by the end of the century. This brings into focus the need for R&D in the area of building materials as they presently constitute around 75 per cent of the cost of the building itself. CBRI is doing R&D in the area of building, building materials and other related areas to fulfill this need. The major areas of R&D at CBRI thus comprise :

Shelter planning

(a) Health buildings
(b) Educational buildings
(c) Rural & urban housing
(d) Night shelters

Structures and foundation engineering

(a) Designs
(b) Testing & evaluation
(c) Repair & rehabilitation
(d) Software development

Hazard mitigation

(a) Natural

Earthquakes
Cyclones
Landslides
Fire

(b) Manmade

Fire

New materials

(a) Wood substitutes
(b) Fly ash bricks
(c) Water proofing compounds
(d) Fire blocking textiles
(e) Termite repellents

Process development

(a) Ecofriendly
(b) Energy efficient
(c) Sustainable development

The methodology adopted at CBRI for handling any R&D programme is identify/ delineate stages of the project; fix achievable milestones; identify outputs; demonstrate the technology/ technique; firm up specs; disseminate information and finally transfer the technology. The major achievements of CBRI include evolving planning guidelines for primary and secondary school buildings, low cost rural houses using local raw materials or improved building materials from natural resources and design and development of economical foundations. CBRI has an excellent fire testing facility, which besides carrying out the statutory testing/ certification, has also developed a number of processes/ products such as fire retardants for aircraft seats and a device for injecting fire extinguishant. It has recently launched a major research programme on 'Fire Loss Minimisation in Buildings and Industries', the outputs of which are expected to be techniques/ technologies for , extinguishing oil fires and metal powder fires such as fire resistant building materials etc. The programme is also expected to generate capabilities in the area of petroleum fire safety, mathematical modelling of fire dynamics, building fire safety etc.

Large quantities of waste from industry as well as from the agriculture sector are available in India. According to one estimate around 40 million tonnes of fly ash from thermal power plants, 10 million tonnes of red mud from alumina plants and 7 million tonnes of slag from iron/ zinc smelters is being generated annually creating disposal problems. CBRI had undertaken R&D programmes on utilisation of wastes, industrial as well as agricultural, to convert them into suitable building materials. The other programmes include biomass gasifiers for drying and firing of bricks and tiles; reclamation of waste disposal sites for human settlements; fixation of toxic/ hazardous materials present in industrial wastes etc.

Constraints in utilisation of R&D results

The major constraint in transfer of technology from R&D organisations is the non-availability of an engineering package with the process technologies. If an engineering package was made available, the acceptability of processes from R&D organisations would increase significantly.

Conclusion

Suggestions for regional R&D cooperation include development of material handling plants/ machines cost effectively; upscaling of bench scale products to commercialisation level; setting up of process demonstration units and training centres for operations and mitigation of fire hazards.

Problems and Constraints Relating to Commercialisation of Processes in Food Sector

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Introduction

CFTRI occupies a key position in the context of national development, especially of the food processing industry while on the one hand CFTRI provides technical inputs to the government for framing policies and programmes to meet peoples expectations, on the other hand it provides inputs to industry in the form of technologies, services, man-power development etc. India is an agriculture dominated economy and the food processing industry has tremendous potential of growth from the view point of availability of raw material as well as of a very large domestic market. Demands on indigenous R&D are generally shaped determined among others by the following factors:

(a) Indigenous raw materials and energy sources;

(b) Socio economic imperatives;

(c) Internal and external markets;

(d) Fiscal and economic policies;

(e) Trade and intellectual property rights regimes; and

(f) Restriction on trading of S&T.

The objectives of CFTRI are thus to:

(a) Develop appropriate technologies to prevent food wastage and extend food supplies;

(b) Improve processes and products to ensure better nutrition;

(c) Harness untapped food resources;

(d) Generate and transfer food processing technologies;

(e) Provide R&D assistance and consultancy services to food industries;

(f) Develop human resources in the food technology area; and

(g) Provide information/ databases in food science & technology to industry.

The services offered by CFTRI include contract R&D, consultancy, trouble-shooting, project/ feasibility/ engineering/ technical reports preparation, project evaluation for financial institutions, machinery selection/ erection/ commissioning, testing and quality analysis, pilot plant production for test marketing, product/ packings development/ improvement/ design, studies/surveys towards on regional agro resource marketing intelligence and training technical personnel,

The draft Technology Policy of India enunciated in 1993, renews the nation's commitment to the use of Science & Technology as key Instruments for national development and aims interalia to:

(a) Emphasise indigenous technology for its accelerated development and use;

(b) Ensure accessibility to technology to wider segments of society;

(c) Enhance infrastructure for technology development;

(d) Upgrade traditional skills; and

(e) Upgrade resources to absorb and adopt newer and emerging technologies etc.

CFTRI is playing its role in translating these aims into activities in the food conservation and processing sector by developing new technologies producing educational facilities in food technology, and training over 400 technical personnel on food processing techniques/technologies etc.

Constraints in utilisation of R&D results

The key constraints to transfer of technologies from research institutes to industry are the apprehension of the industry about the capabilities of such institutions to understand the needs of the industry and to deliver goods satisfying these needs as well as the absence of upscaling facilities in most of these institutions coupled. The non-availability of trained persons in the industry who can translate R&D results into commercial activities is another factor affecting the transfer of technologies.

The measures that need to be taken into consideration by R&D institutes for development of commercially marketable technologies are: (a) R&D output must satisfy market needs for which a study to identify the market needs be done and to convert the same into viable R&D projects; (b) manufacturing practices must be incorporated into the development for its smooth adoption on commercial scale (through pilot plants studies) (c) to set up demonstration plants / prototype units to convince potential clients of the technologies. APCTT could consider establishing demonstration plants/ prototype units on a regional basis in the Asian and Pacific region. Last but not the least is the need to train manpower/ entrepreneurs. This is an important activity for an R&D organisation and would have a multiplier effect on utilisation of its expertise/ services.

Conclusion

Some suggestions on the areas in the food industry where regional cooperation is desirable are: safety of packaging materials, safety of foods, cryogenic grinding, osmotic hydrolysis, health and functional foods etc. Expertise of the countries of the region could be pooled to undertake cooperative R&D efforts.

Encouraging the Increased Utilisation of Locally Available R&D Options

Keynote Address

New Strategies for Commercialisation of R&D Results-Korean Experiences based on the Empirical Studies of Project Analysis of GRIs

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Introduction

The Ministry of Science and Technology (MOST) recognising the effectiveness of cooperative R&D for the rapid utilisation of research results on Government Supported Research Institutes (GRIs) has devised schemes and incentives to promote cooperative programs between GRIs and private enterprises. However, not all cooperative R&D results have been successfully commercialised; a survey indicates that 45.6 per cent of the 162 cooperative projects have been successfully utilised commercially.

Government initiatives

Indigenous R&D as well as technology transfer has been recognised to be critical in developing countries (DCs) and newly industrialised countries (NICs) such as Korea, Singapore, Taiwan, and Hong Kong. Korea has an R&D expenditure of over 2.0 per cent of GNP since 1990, and this is targeted to be raised to 4.0 per cent of GNP by 1998 (Table 1).

As R&D expenditures increase, more careful considerations are given to project selection and strategies for industrial use of research results. Many policies and systems such as cooperative R&D fund service, tax exemption, venture capital augmentation and trouble shooting have played a positive role in enhancing R&D in the private sector and promoting the commercialisation of research results from GRIs. Recent technological environment changes such as the rapid development of new technologies, severe international competitiveness and technology protectionism have imposed on government the need to establish more effective and structured mechanisms to promote the increased utilisation of local R&D performance. The Korean government has initiated some new measures both technological and financial, for utilising research results from GRIs.

Table 1: R&D Expenditure in Korea

Unit : billion Won (1 US$=800Won)

Year	R&D Expenditure	Government Sources	Private Sources	R&D/GNP (%)
1971	10.67	7.29 (68%)	3.38 (32%)	0.31
1976	60.90	39.18 (64%)	21.72 (36%)	0.44
1981	293.13	121.73 (42%)	11.40 (58%)	0.64
1987	1,878.00	383.00 (20%)	1,495.00 (80%)	1.77
1990	3,349.90	651.90 (19%)	2,698.90 (81%)	1.95
1991	4,158.40	815.80 (20%)	3,342.60 (80%)	2.01
1992	4,989.00	878.50 (18%)	4,110.50 (82%)	2.17
1993*	5,200.00	980.00 (19%)	4,320.00 (81%)	2.20

a) Venture capital augmentation for SMIs

Success of R&D commercialisation efforts depends largely on the market demand for the products or processes developed. However as such commercialisation entails far greater risk and much heavier investment than the initial R&D expenditures, the commercialisation of new technologies have been difficult for the small and medium industries (SMIs). Also, till the 1980s, SMIs in Korea had many basic shortcomings, namely, lack of technological capabilities and availability of capital, and trained manpower. These severely affected the limited technology development in SMIs, and also R&D commercialisation. In addition, a majority of the private venture-capital firms formed during the 1980s were against investing in early-stage companies.

Government fostered the setting up of venture-capital firms, the new technology business financing companies (NTBFs), which provided comprehensive financing support for small and medium enterprises with equity investments, loan financing, leasing and factoring services, and the small business investment companies (SBICs) which focused on equity investment during the early stage of start-ups for the first five years of operation.

b) Tax exemptions

In Korea, private firms that invest to commercialise new technologies receive tax exemption of 3 per cent of their expenses, while start-up companies financed by SBICs have 100 per cent tax exemption on their income for the first three years of operation and 50 per cent for the following two years. Another incentive is through government procurement system, in which the government purchases through the non-competitive contracts, products manufactured through new technologies in order to promote their easy market entry and stable production.

c) Corporations for venture business

The Korean Technology Advancement Corporation (K-TAC) was founded in 1976 as the first organisation for venture business in Korea funded by the Korea Institute of Science and Technology (KIST) to promote commercialisation of research results from KIST as well as other GRIs. The Korea Technology Development Corporation (KTDC) was established in 1981 to promote technology development as well as R&D commercialisation in the SMI sector. This was followed by the establishment of the Korea Development Investment Corporation (KDIC) in December 1982, and the Korea Technology Financing Corporation (KTFC) in November 1984. In 1986, the Small and Medium-sized Company Establishment Financing Law was enacted, under which SBICs were established to finance the start-up of small and medium-sized enterprises. KTDC has expanded the scope of venture-capital financing through the provision of such financing instruments as direct-equity investments, convertible debentures, conditional lending and bonds with warrants, and mid and long-term lending services. It also offers follow-up services, such as management consulting, technology transfer, and other technological information services. KTDC also began offering factoring and leasing services in 1989. In 1992, KTDC transformed itself into the Korea Techrology Banking Corporation (KTB) under the Korea Technology Banking Corporation Act and diversified and expanded its financial resources so that it could meet the growing demand for low-cost technology-development financing and support for all stages of R&D as well as R&D commercialisation.

d) Joint research system with industries

MOST has put in place a joint research system through which industries can participate in the projects formulated by themselves with GRIs. The government has also extended R&D subsidies and conducted research jointly with private firms, the results of which are to be commercialised by the participating enterprises.

e) Center for R&D Commercialisation (CRDC)

In 1992 MOST launched the Center for R&D Commercialization (CRDC), whose role is to promote the technology transfer and commercialisation of new technologies from universities and GRIs to industry. Major functions of the center are to promote R&D commercialization by providing financing for research, development, and engineering expenses at favourable conditions, arranging venture-capital investment and offering management and market consulting services for technology-based venture businesses.

f) Business incubator

The concept of a business incubator is to reduce investment cost of venture business and to enhance the success rate of technology-based start-ups. Since most technology-based venture businesses bear a great deal of risk and large investment in the early stage of establishment, it is necessary to lower risk and abate operating costs.

g) Industry-Academy-Research Institute Cooperation Research Center

In order to facilitate the exchanges of technological information and expertise and to seize needs of industry, the Industry-Academy-Research Institute Cooperation Research Center (IARCRC) was established under the organisation of STEPI/KIST. The main functions of the Center are to transfer intellectual properties from GRIs to industries, free of charge (compensation given by the government), offer technological consultation and provide specialised information in various technological fields. For such functions, around 100 study circles were formed in 1993. In October, 1994, the

Technology Development Consulting Center (TDCC) was inaugurated under the IARCRC to meet industrial needs in various technological areas like, assessing research results available from GRIs for upgrading or scaling to desirable economic size.

Cooperative R&D strategies of private sector level

The vertical cooperative R&D has been of increasing interest for developing new technology although firms acquire technologies and know-how through various ways such as in-house R&D, purchasing technology, licensing technology, reverse engineering, imitations, etc. A recent study identifies additional technology development efforts of participant firms to absorb the results of cooperative R&D and to transform them into commercially relevant products or processes. This study which was based on the premise that additional R&D efforts were needed to commercialise the results of cooperative R&D, empirically identified the fact that the participant firms in vertical cooperative R&D with GRIs undertook supplementary R&D of the acquired technologies from cooperative R&D.

The study

The purpose of the study was to examine the relationship between project effectiveness and commercialisation strategies for cooperative R&D by the type of innovation, i.e. project-business relatedness; existing business area versus new business area.

From 1982 to 1989, the Ministry of Science and Technology supported a total of 833 cooperative projects, of which 633 projects were completed and 162 sample projects were taken for analysis. The profile of the 162 projects compared with total projects completed given in Table 2. In the study, commercialisation success was defined as a new product to the firm or a new process technology-market launch success.

Analysis indicates that 74 of the 162 projects achieved commercial utilisation (45.6 per cent), and the commercialisation rate differed by R&D strategic methods employed (Table 2).

Table 2: Profile of the Projects Analysed

Industry	Total No. of Projects	No. of Project Analyzed
Chemical	153 (25.5%)	40 (24.7%)
Machinery	120 (19.3%)	39 (24.1%)
Electrical and electronics	66 (10.6%)	28 (17.3%)
Vehicle (auto and ship)	59 (9.5%)	17 (10.5%)
Material (ceramic, metal, etc.)	105 (16.8%)	17 (10.5%)
Pharmacy	38 (6.1%)	9 (5.6%)
Software	42 (6.6%)	6 (3.7%)
Others	40 (6.6%)	6 (3.7%)
Total	623 (100%)	162 (100%)

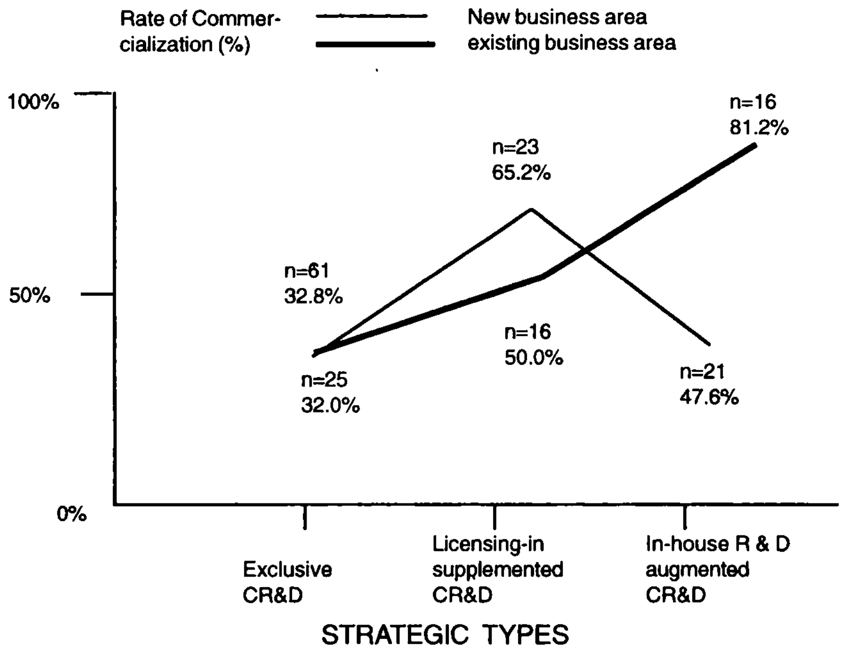
Table 3: Commercialisation Rate by Technology Acquisition Strategies

Technology Acquisition Methods

	Exclusive CR&D	Licensing-in Supplemented CR&D	In-House R&D Augmented CR&D	Total
No. of projects	86	39	37	162
Commercialization rate by strategic type	32.5%	58.9%	62.2%	45.6%

The results (Table 3 and Figure 4) imply that the effeotiveness of commercialisation strategies for cooperative R&D projects vary according to the types of innovation. While in-house R&D augmented CR&D strategies are most effective for projects in existing business areas, licensing-in supplemented CR&D strategy is the most effective for projects in a new business area. The commercialisation rate of the three strategic types by project-business relatedness is given in Figure 1.

Figure 1: Commercialization Rate by Project-Business Relatedness



This study shows that private firms need to exert themselves to utilise other supplementary technology acquisition methods in addition to participating in cooperative R&D with GRIs in order to facilitate commercialisation of the cooperative R&D results. It can also be argued that if a project is closely related with a firm's existing business area, in-house development augmented CR&D strategy is the most effective, and for a new project licensing-in supplemented CR&D strategy. These relationships can be adopted as a basic guideline for private enterprises in technology acquisition to complement cooperative R&D with GRIs. Government is required to be made aware of the capability of firms whether to utilise the other supplementary technology acquisition.

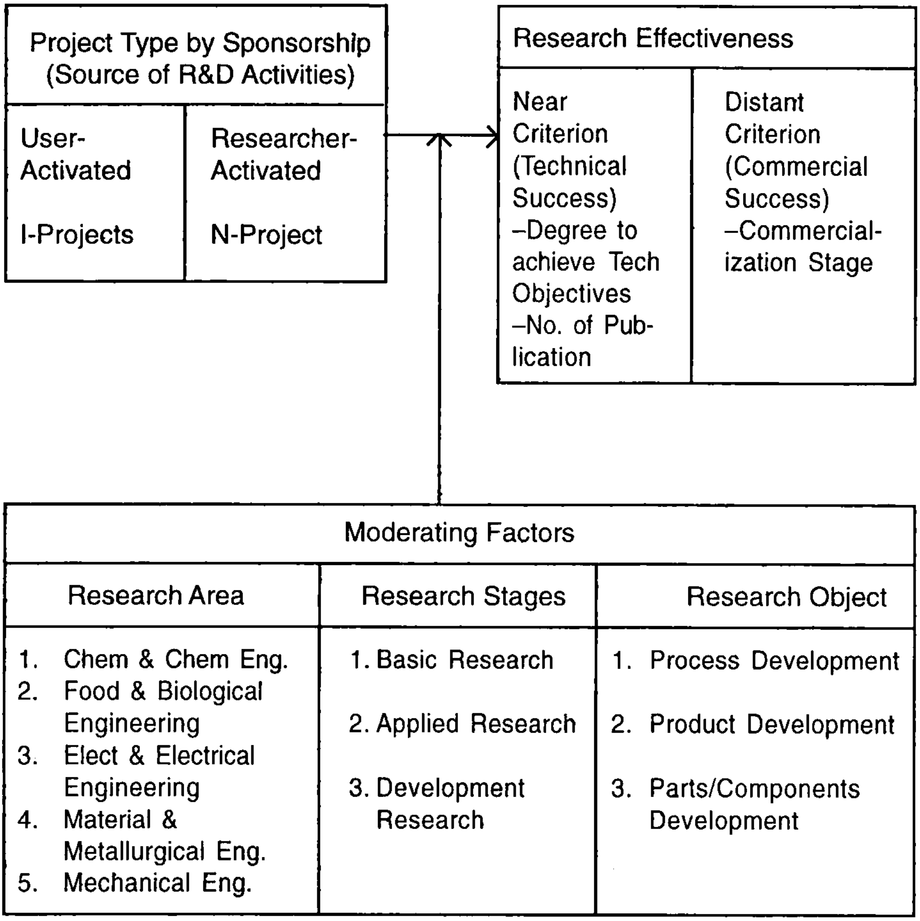
Another study undertaken was on research effectiveness by sponsorship. The study was initiated on the basic assumption that the type of research sponsorship was largely responsible for research effectiveness when specific research characteristics were taken into account, such as research area, research stage, and research object. Research projects sponsored by industry were defined as "I-projects" and national research projects sponsored by government as "N-projects". User-activated research was defined as sponsored by industry and so classified as "I-projects", and it was presumed that market demand was more seriously considered in these type of projects; conversely researcher-activated research was taken as "N-projects" and proposed by research staff and fully funded by government, the motivational factors such as "recognition of technological opportunity" and "recognition of need" were more important in the origination of such research.

The "technology-push" and "demand-pull" innovations were examined from the perspective of research sponsorship and it is possible to compare the effectiveness of the two project types, measured by technical and commercial success, according to different characteristics of research projects. The dependent variable, research effectiveness, consisted of two dimensions, a near and a distant criterion. The near criterion referred to "technical success" and the distant criterion referred to "commercial success" as proven in the market-place. Project type as classified by research sponsorship was considered to be an independent variable directly influencing research effectiveness.

The three groups of moderating variables for the relationship between research effectiveness and research sponsorship were singled out for investigation namely research area, stage and object. The conceptual framework is explained in Figure 2.

The degree to which technological objectives were achieved was measured by a 5-points Likert-type scale where 5 points were awarded for high technical success and 1 to technical failure. The distant criterion of research effectiveness, commercial success, was measured by a 6-point Likert scale in which 6 points were awarded for full commercial success and 1 for no action taken towards commercialisation.

Figure 2: A Conceptual Model of Research Sponsorship and Research Effectiveness



The data set in the study was constructed from the existing database of KAIST projects (1,291 projects) from 1981 to 1988. The relationships between the performance measures and the type of research sponsorship for each research stage are given in Table 4. It is observed that in the case of basic research, researcher-activated projects had a higher degree of achievement of technological objectives than user-activated projects. However, in both applied and development research, user-activated projects enjoyed more commercial success than researcher-activated projects. The effect of research object on

Table 4. Relationship between Research Sponsorship and Research Effectiveness According to Research Stage : T-test Results

Research Stage		Basic Research			Applied Research			Development Research		
Performance Measures	Project Type by Research Sponsorship Sub-items Measurement	User-Activated (I-Project) (N = 30)	Researcher+ Activated (N-Project) (N=43)	T-test p-value	I-Project (N=75)	N-Project (N=72)	T-test p-value	I-Project (N=270)	N-project (N=577)	T-test p-value
Near Criteria (Technical Success)	Degree to achieve Technological Objectives (5-point Liker l scale)a	$\overline{X}$ = 4.0667[b] n = (30) S.D[d]=0.45	4.3250 (40) 0.526	-2.16[c] p=0.034*	4.0267 (75) 0.569	4.3188 (69) 0.528	-3.1 p-0.002**	4.2799 (268) 0.600	4.2784 (528) 0.544	0.03 p=0.973
	Publication in Journals 1. nil 2. one time 3. two times 4. three times 5. more than or equal to 4	$\overline{X}$=0.5200 n= (25) S.D[d]=1.005	3.1250 (40) 1.604	-1.87 p=0.066	2.7818 (55) 1.272	3.3594 (64) p=0.055 1.947	-1.94	2.7531 (239) p=0.002** 1.316	3.1067 (506) 1.602	-3.19
Distant Criterion (Commercial Success)	Commercialization Stage 1. Stop 2. Deferred Stage 3. Supplementary Stage 4. Evaluation Stage 5. Planning Stage 6. Full-Scale Comm.	$\overline{X}$=2.6786 n= (28) S.D[d]=1.986	2.3158 (38) 1.416	0.92 p=0.361	3.6957 (69) 2.031	2.8030 (66) 1.056	3.22 p=0.002**	3.9416 (257) 1.920	3.0352 (511) 1.225	6.89 p=0.0000**

a. A scaled response was sought from one to 5 scale, where 5 meant "very good".
b. Values shown in this row are means for each category
c. All T-values reported are not significant at the 0.05 level, except where noted:
* indicates significant at the 0.05 level ** indicates significant at the 0.01 level
d. S.D. means standard deviation.

Table 5. Relationship between Research Sponsorship and Research Effectiveness According to Research Object : T-test Results

Research Object		Process Development			Product Development			Component/Parts Development		
Project Type by Research Performance Measures	Sponsorship Sub-items Measurement	User-Activated (I-Project) (N = 76)	Researcher+ Activated (N-Project) (N=230)	T-test p-value	I-Project (N=93)	N-Project (N=90)	T-test p-value	I-Project (N=85)	N-project (N=222)	T-test p-value
Near Criteria (Technical Success)	Degree to achieve Technological Objectives (5-point Liker I scale)d	$\bar{X}$ = 4.1711 n = (76) S.D^d=0.598	4.3213 (221) 0.540	-2.03 p=0.043*	4.3407 (91) 0.562	4.2558 (86) 0.557	1.01 p=0.315	4.3059 (85) 0.637	4.2844 (211) 0.547	0.29 p=0.771
	Publication in Journals 1. nil 2. one time 3. two times 4. three times 5. more than or equal to 4	$\bar{X}$=2.4127 n= (63) S.D^d=0.796	2.8756 (209) 1.412	-3.31 p=0.001**	2.7089 (79) 1.460	3.0120 (83) 1.518	-1.29 p=0.197	2.8312 (77) 1.240	3.3480 (204) 1.873	-3.68 p=0.008**
Distant Criterion (Commercial Success)	Commercialization Stage 1. Stop 2. Deferred Stage 3. Supplementary Stage 4. Evaluation Stg. 5. Planning Stage 6. Full-Scale Comm.	$\bar{X}$=3.8056 n= (72) S.D^d=1.962	3.0048 (209) 1.076	3.30 p=0.001**	4.3409 (88) 1.911	3.2381 (84) 1.518	4.20 p=0.0000**	4.0482 (83) 1.652	3.2184 (205) 1.080	4.23 p=0.0000**

Table 6. Relationship between Research Sponsorship and Research Effectiveness According to Research Area : T-test Results

Research Area		Chemistry & Chemical Engineering			Food & Biological Engineering			Electronics & Electrical Engineering		
Project Type by Research Sponsorship Performance Measures	Sub-items Measurement	User-Activated (I-Project) (N = 116)	Researcher+ Activated (N-Project) (N=289)	T-test p-value	I-Project (N=20)	N-Project (N=56)	T-test p-value	I-Project (N=98)	N-project (N=86)	T-test p-value
Near Criteria (Technical Success)	Degree to achieve Technological Objectives (5-point Liker l scale)d	$\bar{X}$ = 4.0862 n = (116) S.D^d=0.612	4.2409 (274) 0.535	-2.50 p=0.013*	4.0500 (20 0.510	4.3636 955) 0.522	-2.31 p=0.024*	4.4021 (97) 0.589	4.3291 (79) 0.548	0.84 p=0.401
	Publication in Journals 1. nil 2. one time 3. two times 4. three times 5. more than or equal to 4	$\bar{X}$=2.4600 n= (100) S.D^d=0.834	2.7663 (261) 1.278	-2.66 p=0.008**	2.6500 (20) 1.040	3.6346 (52) 1.669	-3.00 p=0.004**	2.9101 (89) 1.557	3.7922 (77) 2.178	-2.96 p=0.004**
Distant Criterion (Commercial Success)	Commercialization Stage 1. Stop 2. Deferred Stage 3. Supplementary Stage 4. Evaluation Stage 5. Planning Stage 6. Full-Scale Comm.	$\bar{X}$=3.1826 n= (115) S.D^d=2.105	2.8774 (261) 1.174	1.46 p=0.147	3.1000 (20) 2.174	2.8679 (53) 1.345	0.45 p=0.659	4.1318 (91) 1.922	2.5250 (80) 1.396	6.89 p=0.0000**

Table 6. (Contd.) Relationship between Research Sponsorship and Research Effectiveness According to Research Area : T-test Results

Research Stage		Material & Metallurgical Engineering			Mechanical Engineering		
Project Type by Research Performance Measures	Sponsorship Sub-items Measurement	User–Activated (I-Project) (N = 73)	Researcher+ Activated (N-Project) (N=152)	T-test p-value	I-Project (N=79)	N-Project (N=84)	T-test p-value
Near Criteria (Technical Success)	Degree to achieve Technological Objectives (5-point Liker l scale)d	$\overline{X}$ = 4.1918 n = (731) S.D[d]=0.659	4.3185 (135) 0.568	-1.45 p=0.149	4.0641 (78) 0.566	4.3077 (78) 0.542	-2.75 p=0.007**
	Publication in Journals 1. nil 2. one time 3. two times 4. three times 5. more than or equal to 4	$\overline{X}$=2.9322 n= (59) S.D[d]=1.271	3.2266 (128) 1.802	-1.28 p=0.202	2.5692 (65) 0.935	2.9267 (75) 1.120	-1.46 p=0.146
Distant Criterion (Commercial Success)	Commercialization Stage 1. Stop 2. Deferred Stage 3. Supplementary Stage 4. Evaluation Stage 5. Planning Stage 6. Full-Scale Comm.	$\overline{X}$=3.4923 n= (65) S.D[d]=1.804	3.3721 (129) 1.219	0.48 p=0.629	3.7632 (76) 2.084	2.8026 (76) 0.980	3.64 p=0.0000**

the relationship between project sponsorship and the effectiveness is given in Table 5.

In the case of process development research, researcher-activated projects were more successful technically than commercially, while the reverse was true for user-activated projects. In cases of product development, however, the levels of technical success were similar for the two project types, while commercial success differed significantly. User-activated projects had a significantly high level of commercial success. Parts/components development showed a pattern rather similar to that of process development except that one of the measures of technical success, the degree of achievement of technological objectives, did not differ significantly between the two project types. The distribution of research areas by research sponsorship is given in Table 6. The I-projects were distributed fairly equally among most of the research areas except the area of food technology and biological engineering.

The results lead to two main implications: (1) the management of research projects in developing countries should take a contingent approach to make their R&D successful. Project managers and other related researchers should take into account the entire situation and nature of the research stage, research object, and research area, he explained; (2) project developers and managers in developing countries should give careful consideration to the continuing debate about the relative importance of "technology-push" and "demand-pull" in determining patterns of innovative activity, and in triggering innovative activity. Finally, it is necessary to replicate these kind of studies in different institutional settings as the pattern observed in a government-supported research institute in Korea need not necessarily prevail in other countries.

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Encouraging Increased Utilisation of Locally Available R&D Options for Industrial Development - Indian Experience

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Introduction

Science and Technology (S&T) has contributed significantly to improve the quality of life all over the world; there are great expectations from S&T developments for the benefit of the common man in India.

Technological changes are taking place at greater pace now. Technology is perhaps the most important resource to any nation in wealth creation and making countries economically stronger. Scientific Research and Development R&D) is therefore a very important activity to ensure that the expectations of society and industry are actually met in a reasonable time frame. In this context a close cooperation between the R&D community and enterprises for technology development, commercialisation and application of R&D results is of great relevance.

The Indian Govemment in 1991 announced major policy changes to make the Indian economy and industry globally competitive. In the changed scenario, Indian industry has options to import technologies from abroad, establish stronger links with the national R&D system as well as develop their own technologies to meet the challenges.

Government policies and initiatives

Recognizing the role of Science and Technology in national development, the Indian Government has, from time to time, evolved various policy initiatives to create a conducive environment to promote Science and Technology in the country and create technological capabilities. These include : the Industrial Policy, Scientific Policy, Technology Policy and Education Policy. The other supporting policies such as Fiscal Policy, Trade Policy, Labour Policy have also had an indirect bearing on enhancing domestic technological capabilities.

Industrial policy

India's Industrial Policy Resolution of 1948 conformed to the policy of the State in promoting a socialistic pattern of society. Major changes in the industrial policy were brought out through the Statement on Industrial Policy, 1991. The essential features of the new Industrial Policy were : industrial licensing abolished for all projects except a short list of industries; automatic clearance of capital goods imports; discontinuation of phased manufacturing programme; encouragement to foreign investments and technical assistance. The public and private sectors are today perceived as supplementary and complementary to each other.

Scientific policy

The Scientific Policy Resolution of the Government of India announced in 1958 stressed that the key to national prosperity lay in the effective combination of three factors namely : technology, raw materials and capital. The scientific policy has remained unchanged as every word in the policy is relevant even today.

Technology policy

The Technology Policy was announced through the Technology Policy Statement (TPS) of 1983. The basic objectives of the Technology Policy include the development of indigenous technology and efficient absorption and adaptation of imported technology appropriate to national priorities and resources. However, the new economic, industrial and trade policies announced by the government subsequently made, some parts of the TPS obsolete, he said.

National R&D infrastructure

Government has set up vast a S&T infrastructure comprising a chain of national laboratories of the Council of Scientific and Industrial Research (CSIR), Indian Council of Medical Research (ICMR), Indian Council of Agricultural Research (ICAR), Defence Research and Development Organisation (DRDO), Atomic Energy Commission, Indian Space Research Organisation (ISRO), Universities, colleges, IITs and also cooperative research associations in selected industrial sectors such as textiles, jute, cement and building material, rubber, automobiles etc. with active participation of industry. Industry also has set up over 1200 in-house R&D centres and also supports around 400 scientific and Industrial Research Organisations (SIROs).

Support systems

The government has created several systems for R&D and commercialisation of technologies. National Research Development Corporation (NRDC) under the Department of Scientific and Industrial Research (DSIR) is mainly engaged in licensing and commercialisation of indigenous technologies as well as export of technologies. Department of Space, Department of Atomic Energy and few others have also set up independent technology transfer mechanisms for industrial applications. Consultancy Development Centre (CDC) at New Delhi and State Technical Consultancy Organisations in many states to promote consultancy and enhance the role of consultants in industrial and technological developments have been established. Financial institutions such as Industrial Development Bank of India (IDBI), Industrial Credit and Investment Corporation of India Limited (ICICI), Industrial Finance Corporation of India (IFCI), and banks provide assistance for commercialisation of indigenously developed technologies and adoption of imported technologies through venture capital companies such as Technology Development and Information Company of India (TDICI) and Risk Capital and Technology Finance Corporation Limited (RCTFC). Tool Rooms and Prototype Development Centres, Test Centres, Design and Development Centres, Information Centre for Patents and others including technology data bases have been established. The Bureau of Indian Standards has evolved national standards and specifications for a host of items being manufactured in the country for the domestic market and for export.

Human resources

Qualified and trained manpower are essential for making technological advancements and utilising R&D results for industrial development. Indian universities and colleges are producing qualified manpower for research and technical activities. The estimated total stock of S&T manpower was around 40 lakhs in 1990.

Research and development by industry

Government has taken several measures towards promoting industrial research in industry itself. Several incentives have been provided which encouraged and made it financially attractive for private, joint and public sector industrial units to establish their own in-house R&D centres. A scheme for granting recognition to in-house R&D units in industry was initiated in 1973 under the Dept. of Scientific and Industrial Research (DSIR). Presently there are 1230 in-house R&D units in industry duly recognised by DSIR incurring an expenditure of around Rs. 1300 billion (1993-94) and employing around 50,000 S&T personnel. The share of the public sector is 45 per cent and that of the private sector is 55 per cent.

Commercialisation of R&D results

Industry has commercialised a number of domestic technologies and regular production units have been set up for production of a variety of items based on these technologies. DSIR has issued as many as 300 certificates valued at around Rs. 500 billion on plant and machinery set up by industry since 1977 for commercialisation of indigenous R&D. Such units certified by DSIR are eligible for accelerated depreciation allowance on the cost of plant and machinery.

Programmes aimed at encouraging increased utilisation of locally available R&D options

In the liberalised environment a higher degree of indigenous technical, technological and professional inputs are required to be put in place. Several government departments had already initiated a number of programmes to promote domestic R&D and technology development. DSIR has also initiated several programmes/schemes to encourage increased utilisation of locally available R&D such as Programme Aimed at Technological Self Reliance (PATSER), Scheme to Enhance the Efficiency of Transfer of Technology (SEETOT), and National Information System for Science and Technology (NISSAT). Besides DSIR is also supporting several technology development/absorption/assessment and technology demonstration programmes in industry through the active involvement of the National Laboratories, Universities and IITs and National Research Development Corporation. DSIR has played an important role towards evaluation of technology status in a wide range of industrial sectors. Technology status and norms reports, technology profiles of several countries, consultancy capabilities, in-house R&D capabilities, numbering over 250 have been published DSIR has also set up National Information Centres in various areas such as chemicals, drugs and pharmaceuticals, textiles, leather, food etc.

R&D community - Enterprise cooperation for technology development and commercialisation of R&D results

Effective interaction and stronger linkages between S&T and R&D agencies, industry, government, consultants, financial institutions and users are very essential to make indigenous R&D effective and also to optimise the inputs for R&D. The economic ministries and scientific departments need to interact to optimally utilise the S&T allocations and for a focused and greater thrust on identified strategic programmes for faster technological advancements to make industry competitive. Though a number of departments and agencies are promoting and supporting R&D programmes for industrial development in the country, there is no centralised agency to coordinate government supported industrial R&D programmes for their effective commercialisation. There is a need to have such a set up within the Department of Scientific and Industrial Research. The set up could also include a national information pool on industrial R&D projects being pursued in the country.

Conclusion

Though there have been a number of examples of utilisation of domestic technologies for industrial development there was still greater need and scope for increased utilisation of locally available R&D options in the changed scenario. There are several initiatives for enhancing domestic technological capabilities and enhancing increased utilisation of locally available R&D options some of which include : (a) prioritising technology development programmes; (b) strengthening engineering and product design capabilities; (c) updating syllabi and modernising facilities in educational institutions and industrial training centres; (d) motivating and encouraging R&D personnel; (e) strengthening technological information databases and systems to meet the growing needs; (f) initiating multi-agency R&D programmes to bridge the gaps; (g) evolving effective mechanisms for coupling S&T programmes and outlays of the Economic Ministries with the S&T systems; and (h) establishing a nodal cell to coordinate all the Government supported industrial R&D programmes.

While there are good examples of R&D community - enterprise cooperation for technology development and commercialisation of R&D results in some areas, a lot more remains to be done and achieved to effectively utilise the impressive domestic R&D capabilities and expertise in making Indian industry globally competitive. The prospects appears to be bright and challenging.

Strengthening Cooperation for Promoting Commercialisation of R&D Results in the Region

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Introduction

Although technology transfer generally involves payments, in China charging for technology is phenomenon of recent origins. Earlier the R&D output generated at the research institutes was transferred to the enterprises free of charge by the administration under the unified planned management mechanism. Then special law on technology contracts was formulated and put into effect in 1987 to guide and normalise the behaviours of the concerned parties or individuals involved in technology transfer. The law defined four kinds of technology contracts, namely technology development contract; technology transfer contract; technology consultancy contract and technical service contract. The government has formulated and issued model contracts for users' references.

Technological trade in China has swiftly and steadily developed since the mid 1980's. In 1993 it was around 20 billion Yuan RMB, (2.3 billion US$) which was ten times higher than the 1986 figures. Out of the total amount of 20 billion Yuan of technological trade in 1993, technology development trade accounted for 34 per cent, technology transfer 13 per cent, technology consultancy and technical service were respectively 9 and 44 per cent. In China, research institutes, universities, enterprises (with the capability of technology development) and technology transfer (trading) agencies are the main sources of technology. In 1993 the technologies transferred from these organisations accounted for 40, 8, 16 and 28 per cent respectively. In fact, the technology transfer agencies are an indirect source of technology in China.

Main channels of the application of R&D results

The Chinese government has focused on economic development since the 1980s and thus emphasised development of science and technology. As the highest national authority for science and technology in China, SSTCC has launched several programs to promote the application of R&D results to strengthen the economy. The Spark program and torch program are two of them. The Spark program is aimed at promoting the application of appropriate technologies in the small and medium sized enterprises. The Torch program aims at promoting the commercialisation of hi-tech results and developing high value-added products. Several sectors such as new materials, electronics, mechatronics and biotechnologies are identified as the preferable development fields in this program.

The improved economic operational mechanism has encouraged many R&D institutes and individual inventors to develop appropriate technologies based on market analysis and demands of market place. The information about technologies developed is disseminated through technology information periodicals, publications, technology fairs and technology transfer agencies.

The specific aspects and issues on the technology transfer process

Though the technology transfer process is multi-faceted there are two key components of identifying a research institute's technology that is appropriate for transfer and; developing a relationship with a potential partner. When a researcher's innovation is utilised by an entrepreneur the technology transfer that occurred is between them. In such cases the technology transfer process matches the users' needs with the innovation. Many entrepreneurs and established businesses have the capability to bring new and improved technologies to production, but they may lack the capability to develop those technologies themselves. In many cases research institutes are technology suppliers to these new enterprises.

Technology transfer is a multi-step process and any or all of the steps might occur in any particular transfer. These steps include : finding out what was available and what was needed; adapting technology to the needs of potential partners; pricing technology; evaluating technology transfer risks; establishing a negotiating position; negotiating the technology transfer; transferring the technology; maintaining a long-term relationship with the counter-partner and; assessing a long-term arrangement.

(i) Identifying technology for transfer

Technology within a research institute must be assessed and then a relationship established with a potential partner for technology transfer.

(a) Finding out availability and requirement

The first step in the technology transfer process is to determine who has what to offer and who needs what. It is essential to understand what is on to offer. It is necessary to develop a detailed list of what is available and what is needed; items on the list should be grouped into categories such as: technologies under development; technologies ready for transfer; products under development; inventories ready for transfer; processes under development; processes ready for transfer; services available; and facilities available. A complete assessment of technology transfer opportunities must be carried out which should take in account competencies of a particular supplier.

(b) Adapting the technology to the market needs

Technologies are brought to market because a businessman/entrepreneur perceives a need for that technology. If a businessman plans well and researches the need of a target market, there might be a viable business based on that technology. There are many situations in which a technology needs to be modified to meet the requirements of a recipient and/or of the marketplace. Ideally any technology transfer agreement anticipates such requirements and sets forth conditions under which the parties work together to complete the required technology modifications.

(c) Marketing

When sufficient information is gathered on available technologies and needed technologies, the potential technology recipients need to be informed about technologies, product, processes, and/or services available. There are many ways to inform potential recipients of what is available. These include : written materials; demonstrations; talks/seminars by the research staff etc. The specific technology and its potential applications determine what marketing methods are best for advertising the technology to the target market.

Creation of a partnership or joint venture with another organisation to demonstrate the technology or to bring the technology to market on a trial basis is most necessary.

(ii) Evaluating available technologies and partners

Technology can only be brought successfully to the market if it works/fulfills users' needs, is transferable, and technology recipients have the resources, labour and necessary finances. In-house technologies need assessment to determine whether they are worth being brought to the attention of potential technology recipients. There also needs to be an assessment of the skills required to bring that particular technology to a proposed technology transfer arrangement. At the same time, potential technology recipients need to determine what technologies they require, to take advantage of opportunities in the marketplace. They must also assess the resources (labour, raw materials, equipment, financing) that would be needed to bring the technology to the marketplace and determine which of those resources they can provide. Recipients also need to determine which resources they cannot provide and find out where such resources are available.

(a) Pricing the technology

The setting of price for technology, products, process or service is a crucial step in the business planning process. An effective price should be one that a purchaser deems reasonable and affordable, which at least covers the seller's operating expenses, and provides a modest profit. If a similar product is already selling in the marketplace, compare the benefit of that product with the benefits of the new product intended to be launched. According to the price of the existing product, the new product needs to be adjusted up or down the pricescale to reflect its value. If there is no similar product already being sold, it is more difficult to arrive at a reasonable price. A survey could be carried out of potential purchasers to get a feel of what they would consider a reasonable price for the product.

(b) Evaluating risks

Different types of risks are generally associated with any transfer of technology. Each risk must be assessed carefully. The possible risks might be: technological risks; health and safety risks; environmental risks; business risks and social risks.

(c) Establishing a negotiating position

After evaluating the technology, and each other's respective position, each party should independently decide the ideal vision of the technology transfer arrangement. Both parties need to come away from signing the transfer agreement believing they been treated fairly and that they will benefit from participating in the transfer arrangement. There are many issues which should be addressed properly while negotiating. The technology transfer agreement should describe the obligations of all parties to the agreement like who is getting rights to what technologies, for what use, as well as the amount and timing of payments.

(iii) Developing a technology transfer relationship

(a) Supporting the technology transfer agreement

For technology transfer to be a success for both supplier and recipient, the technology must be transferred in a way that enables the recipient to implement the transferred technology effectively. And a recipient to receive and successfully implement a technology requires the following in addition to the technology, through documentation describing: how to use the technology; hazards that could occur from improper manufacture, assemble and/or use of technology; information on where to get assistance if the technology did not work as expected; problem diagnosis; troubleshooting techniques; availability of on-going consultation with the technology supplier; training, as needed to help the recipient make and sell the product and marketing. While entering into a technology transfer arrangement it is important for the recipient to carefully determine what he would require in order to implement the technology. And at the same time, the supplier must ensure that all the components are provided to the recipient.

(b) Maintaining long-term relationship between the parties to the parties to the technology transfer

All successful technology transfer arrangements create an on-going relationship between the parties. The relationship will last, at least as long as the term of the technology transfer agreement is in place and its effectiveness will be determined by both parties willingness to make the relationship a success.

(iv) The role of technology transfer agency and promotional organisation

The high cost of acquiring rights for a specific technology could be a significant barrier to access of needed technology. Therefore, developing nations should strengthen cooperation to find technological solutions available locally at reasonable costs.

Conclusion

The ability to create jobs and wealth using locally developed technologies is an important part of developing national self-reliance and sustainable economic growth. Simply providing funds to develop technologies in research institutes does not guarantee that technologies will be developed for use within the country. Technology development can be a very costly and time-consuming process. However when it is complete, significant additional financing and time might be necessary to adapt a technology to meet market needs. To maximise the chance of technology uptake and use within a marketplace, a system stimulating interaction between developers and users of technology must be put in place. Strengthening cooperation for promoting technology transfer in the region is a much desired action to be put in place urgently. APCTT could catalyse activities in the region.

Encouraging the Increased Utilisation of Locally Available R&D Options : Sri Lankan Case

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Introduction

The growth of scientific activities during the 18th and 19th centuries, often referred to as the scientific revolutions, highlighted the importance of R&D for a strong economy. This prompted many nations to devote resources increasingly to R&D and to utilisation of the results of R&D for industrial development. Sri Lanka recognised the importance of R&D for building a strong national economy and has accordingly evolved polices and created an infrastructure for indigenous R&D. Sri Lanka's S&T policy broadly consists of four constituents namely :

i. creating and providing inputs for R&D in terms of research infrastructure, materials, trained and qualified human resource and strategic measures for deploying the available resources;

ii. determining national research priorities for the well being of its people;

iii.prioritising needs for industry competitiveness through high intensity research on selected industries; and

iv.ensuring medium and long term research in life sciences and frontier areas.

Research capability in terms of qualified and trained research personnel have been declining sharply over the years with the number of scientists and engineers in 1990 reducing to just 50 per cent of 1985. Further though there has been a general increase in levels of funding for R&D, in real terms these increases are marginal and not in pace with the growth of the gross domestic product. In fact R&D expenditure has fallen to 0.13 per cent in 1990 from 0.2 per cent in 1975.

Infrastructure facilities for R&D

R&D laboratories were first set up for the plantation sector by Britishers; today research and development activities are being performed by a number of state organisations placed under different ministries and though there is no single assigned body for the overall planning and co-ordination of science and technology activities, plurality and diversity of organisational structures have not affected the implementation of science based programmes. The R&D institutional frame work in Sri Lanka comprises:

i. Agriculture and veterinary science research

Agriculture research is conducted primarily on a regional basis. The Department of Agriculture ias responsible for the development and dissemination of new technology for the small farm sector in Sri Lanka through six technical divisions and their extension centres. The Veterinary Research Institute carries out research in animal husbandry and veterinary diseases.

ii. Forestry, wildlife and fishery research

Research in forestry, wildlife and fishery is less extensive and is carried out by the Department of wildlife, and the National Aquatic Resource Agency (NARA)

iii. Health and nutrition research

Medical Research Institute (MRI) with the biggest laboratory complex carries out research in the area of health and nutrition.

iv. Industrial and mineral research

Research in industrial activities and mineral resources is carried out by various institutions under the Ministry of Science and Technology namely Ceylon Institute of Scientific and Industrial Research (CISIR), National Engineering and Development Centre (NEDC), Geological Survey Department, Atomic Energy Authority etc.

CISIR is the largest industrial research organisation in the country set up in 1955 to provide inter alia S&T expertise and services for the development of industrial processes/ testing services, utilisation of natural resources, training of research workers etc. The Institute's mission is 'To promote technological and industrial growth through demand driven R&D and internationally competitive technical services leading Sri Lanka to Newly Industrialised Country (NIC) Status'. In a bid to rationalise its resources towards greater efficiency, the Institute has reorganised its 13 research sections into five divisions and two units last year. All divisions and units have an industry oriented outlook and carry out industry support activities. The process and plant engineering division consisting of a Pilot Plant and Workshop with Engineering expertise undertakes plant design, fabrication, layout, installation and commissioning. A corporate services division has been created to promote the Institute's corporate image and to market the Institute's existing services as well as identify new opportunities for the Institute. With the new orientation, industry can now look forward to a mutually rewarding and beneficial relationship with the CISIR.

The other scientific institute, the National Engineering Research and Development Centre (NERD) was established in 1974 to promote indigenous technology through coordination of technological, engineering and research capabilities of various public and private sector industries and to advise and assist in adoption and assimilation of technologies consistent with the country's resource endowment. Apart from these scientific institutions, about 40 manufacturing and service corporations operate under the Ministry of Industries.

An Industrial Development Board (IDB) has been set up as the main extension services wing of the Government with branches to provide a package of integrated services for small and medium scale industries. Besides these main agencies there are several other scientific and technological service organisations and universities performing small components of R&D.

Dissemination of R&D results

Dissemination of R&D results in the agriculture sector is being done by the Extension Service Centres of the Department of Agriculture or Crop Development Authority. CSIR through contract research, consultancy etc. provides extension services in other industrial sectors such as agrochemicals, agro based consumer products, building materials, food, industrial chemicals and products, industrial plant and machinery, industrial waste management, paper and pulp, plastic etc. The Industrial Development Board assists the development of small and medium scale industries through training programmes, technical consultancy, feasibility study etc.

Financial support for utilisation of R&D results

In order to promote use of indigenous R&D expertise financial assistance schemes for obtaining technological assistance from local R&D institutions are being operated through national banks and financial cooperations. The projects funded by the US Aid Schemes like SMED (Small and Medium Entrepreneur Development) and Agent (Agro Enterprise Development) also offer financial assistance to the industrial sector for acquisition of technical knowhow, training and market development, from local research organisations. A grant referred to as the Technology Transfer Fund established under a Small and Medium Industries (SMI) Project provides financial assistance on a grant basis to SMI to help upgrade technology and solve technology related problems, training and acquisition of knowhow.

Constraints in utilisation of R&D results

i. Agriculture and plantation sector

Utilisation of R&D results/knowledge is influenced by many factors. A study conducted in Sri Lanka on acquisition, perception and transfer of S&T knowledge and R&D results, reveals that in the increasingly competitive agricultural economy, the sharing or diffusion of R&D results among the growers is taking the back seat. Thus the 'lead farmer concept' adopted by Department of Agriculture to diffuse R&D results has not proved successful. The weak resource base of a majority of farmers is another constraint in promoting advanced techniques of agriculture emanating from R&D. There is also a general ignorance of the new techniques/ developments among the formers and even if knowledge is available, some of the farmers are too tradition bound to try new developments.

ii. Manufacturing sector

The constraints affecting the utilisation of local R&D results in the manufacturing sector are indicated in a survey of industries carried out by CISIR in 1990. The survey covered 152 industrial units, 63 private limited companies, 32 partnership enterprises, and 20 family businesses. It was found that the experience, education and skill endowments of shop-floor workers in Sri Lankan industry is low as a result the R&D result assimilation and utilisation capacities of the Sri Lankan industry was rather poor. Further the work force apart from on-the job experience, has had very few opportunities to obtain/ upgrade formal training in either technical or managerial skills which is a constraint in their accepting innovations. With regard to Small and Medium

Industries (SMIS) it was revealed that there is a lack of access to information on new technologies/ R&D results as well as a lack of skilled workers and technicians in industry. Also the fact that upgradation of technology involves investments and credits being difficult to obtain, discouraged SMIs to go for new development from R&D. In a sectoral study of industrial units in the area of food processing, metal products, wood products, rubber products and electronics, it was revealed that often the outputs from R&D institutions are either out of date, too academic or not commercially viable and thus not applicable. Frequently research and development was found to have been undertaken without any market research to determine whether there was likely to be a demand for the output. The existing environment and banks policies are also conducive for an entrepreneur to obtain financial assistance to set up industry using imported technology which was well proven rather than using locally developed technology as in most cases it is on a laboratory scale with no proper scaling up even to pilot plant level. Further, at present there are neither any incentives for an entrepreneur to use locally developed technology nor any mechanism by which he could be compensated for any losses incurred, in the event of a failure.

Conclusion

For effective utilisation of locally developed R&D, the following issues need to be addressed:

The primary thrust of the national development efforts should involve strengthening of industrial technology bases for which adequate support must continue to come from indigenous R&D organisations. There is a need to strengthen facilities for applied and adaptive R&D both at the laboratory and the pilot plant levels as well as to facilitate technology transfer through demonstration of technologies and or offering them on a turn-key basis. The R&D institutions need to keep themselves updated on industry needs and new technological developments worldwide. Human resource development through training and upgrading knowledge and skills is an essential component to facilitate use of R&D knowledge/ output. It is essential to institute higher remuneration monetary incentives and recognition systems for scientific and industrial achievements by scientists to check brain drain. Lastly there is a need to orient tertiary education to meet the science and technology requirements of the industry.

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Renovation of Science and Technology Management to Improve Research and Development and its Applications

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Introduction

Vietnam initiated economic reforms in the late 80's by moving towards a market-oriented economy. The new economic policies placed a great demand for improvement of the Science and Technology systems in Vietnam.

R&D systems in Vietnam

The R&D network of Vietnam, all in the public sector, consists of research institutes and centres under the various Ministries and State Committees, research organisations and centres of geographical and economic regions, research centres and organisations under the universities. Vietnam possesses a large pool of S&T personnel numbering around 400,000 with a basic degree in science and engineering; of these around 7,000 with PhD degrees and about 23,000 people work in about 220 R&D organisations in the country.

The drawbacks of the R&D system are :

(a) Limited freedom to R&D organisations to sign R&D contracts with production organisations;

(b) Absence of any pecuniary incentives to encourage the cooperation between the R&D community and the production sector as well as for application of new research results;

(c) No encouragement for carrying out of R&D activities by private and cooperative sectors; and

(d) Reduced effectiveness of the use of budget investment for R&D activities.

Reorganisation of the R&D system

Recognising the weaknesses of the centrally planned economy, the government of Vietnam and organisations engaged in R&D management have promulgated various policies to eliminate these weaknesses:

(a) Creating a favourable environment for all people and organisations to conduct R&D activities and apply R&D results by ensuring freedom and equality for all organisations in R&D activities;

(b) Encouraging joint ventures, cooperation and integration between R&D and production and business. The forms of joint ventures, cooperation and integration can be organisational set ups for application of new technologies or advancements and centres for transfer of technologies or application of technologies;

(c) Improving financial management tools through taxation policies envisaging tax exemption or deduction for R&D contracts, experimental and/or pilot production to test newly developed technologies, and permitting R&D organisations to seek loans from banks;

(d) Supporting pilot/ experimental production projects on contract basis by the Ministry of Science, Technology and Environment.

Conclusion

These measures have systematically improved and enhanced R&D activities and implementation and helped forge relationships between the R&D community and enterprises.

Encouraging the Increased Utilisation of Locally Available R&D Options: Bangladesh Experience

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Introduction

Organised research and development (R&D) is an indispensable tool for economic development of a nation. In Bangladesh the government has played a major role in financing and directing R&D activities.

Bangladesh Council for Scientific & Industrial Research (BCSIR)

It is a semi-autonomous body under the Ministry of Science & Technology. It now comprises three laboratories at Dhaka, Rajshahi and Chittagong, two mono-discipline institutes namely Institute of Fuel Research and Development (IFRD) and Institute of Food Science and Technology (IFST), and a Pilot Plant and Process Development Centre (PP & PDC). The overall management of BCSIR is vested in a Board comprising a full time chairman, four full time members, and four part time members. An advisory council, headed by the Ministry provides guidance to the Board. BCSIR has about 1300 employees of which 300 are scientists and engineers, 120 are technicians and 275 officers. Like other developing countries of the region, the government has laid emphasis on self-reliance which sets the following agenda and priorities for research by BCSIR:

(a) research in basic science in order to attain autarky in science and technology;

(b) research in indigenous raw materials in order to achieve economic self-sufficiency through import substitution; and

(c) development of indigenous technology, rather than assimilation and adaptation of imported technology.

These objectives / policies are probably better suited to large and resource-rich countries, and not to smaller and resource-poor countries like Bangladesh.

The thrust of research in the BCSIR in its early years was mainly on chemical investigations of the natural raw materials of the country and gradually the emphasis has shifted to "Applied Investigations". The two mono-discipline institutes from the very beginning have been concerned mainly with application oriented research. However, a very large percentage of BCSIR research is at the stage of laboratory investigations; only a few relate to process development leading to commercial plants or engineering. Thus of the 236 processes patented so far by BCSIR, 149 are licensed and only 29 processes are reported to be in use.

Technology policies

Although the government has created an adequate R&D infrastructure, its policies are not conducive to their optimum use on account of (i) the role of BCSIR not being appropriately defined in the context of the National Technology Development Policy, and (ii) government enterprises freely importing foreign technology, ignoring local research capabilities/outputs. Government enterprises do not even appreciate the need to build up their own design and engineering capabilities. Also Bangladesh is seeking to integrate itself into the world markets on the basis of its relative advantage in labour and energy (gas) cost. BCSIR with its commitment to utilisation of local raw materials is thus out of step with the country's development process.

Constraints in utilisation of R&D result

The constraints being faced in commercialisation of technology by BCSIR are lack of perceived need for technologies, small market size, incomplete development of technology, assessment of cost of technology, availability of alternative technologies at lower cost, inadequate publicity and communication etc. Human resources are another factor for success in R&D. However the present state of human resources of BCSIR is not encouraging. Of the nearly 306 researchers, only one sixth are PhDs and half of them are due for retirement in the next five years. The composition of the staff in terms of scientists, technical and other persons is in the ratio of 24:8:68. Thus BCSIR is numerically dominated by non-scientific personnel which not only drains financial and other resources, but is also largely responsible for the absence of a very congenial research atmosphere. Shortage of research funds has always been a constraint to the research, development and commercialisation activity of BCSIR. A major part of BCSIR's budget until recently, was allocated for non-research items, such as salary, repair and maintenance. At present, the government is almost the only source of funds; industry provides a negligible part of the research budget.

Conclusion

To overcome these constraints :

(a) Bangladesh needs a comprehensive technology policy which focuses on rapid assimilation of imported technologies and at the same time creates incentives for development and application of indigenous technologies;

(b) The technology policy needs to be supported by an adequate institutional framework including legal and fiscal measures;

(c) An organisation should be setup, in the public sector, to finance pilot plant developments and foreign technology assimilation;

(d) Human resource development needs to receive the highest immediate priority.

Diversity of Experiences and Possibilities of Furthering Multi-country and Multi-enterprise Partnerships

Introduction of Theme with Particular Reference to Latin-American Experiences

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Division for Economic Cooperation among Developing Countries and Special Programmes, UNCTAD

Introduction

Abundant literature exists on the cooperation between the R&D- community and the enterprise sector in developed countries. Although such cooperation is not a new phenomenon, new forms of interaction are taking shape in these countries, in response to changes in the international marketplace. Firstly, cooperation between enterprises has multiplied mainly in reaction to the increasing costs and economic magnitudes of complex R&D endeavours. Secondly, the university-enterprises cooperation has not only accelerated, but has also become smoother in the light of longer-term dimensions of technological change. Thirdly, the interaction and multifaceted forms of contracting between the private entrepreneurial sector, and the public universities and laboratories, have become more frequent. The multi-country and multi-enterprise character of these arrangements has become more pronounced, and has transcended sub-regional and regional boundaries. But these trends are only incipient between the developing countries, and might be regarded as one of the weaknesses in the field of technology observable on a worldwide scale. Some aspects of the Latin-American experience may assist in illustrating these issues.

The Latin-American setting

A series of contributions by Latin-American experts to a Workshop held in Buenos Aires, from 17 to 19 March 1993 on the subject of university and enterprise relationships in a new competitive scenario, have described and analysed the Latin-American setting. A number of extra regional experiences were also presented at that Workshop, serving as a basis for discussions on the characteristics of interactions. The debates suggested that the evolution of the relationship between universities and enterprise in Latin-America reflected a different logical approach than that prevailing in the developed countries, and that several economic and social factors intervened in these relationships, many of which could be interpreted as forming part of a much broader "technology gap". The lack of specific institutional structures, insufficiencies in the skill and human resource profiles, lack of promotional instruments for innovation, poor synergetic interactions, coupled with diminishing resources for technological development purposes, are but some of the shortcomings portraying the Latin-American situation in the early 1990s.

New horizons for cooperation

The pace of technological change has been accelerating rapidly over the past thirty years. This has expanded the number of products on the international marketplace, in many instances improving their quality, or reflecting new insights or requirements of an economic or technical nature. Technological dynamism has been much greater in the developed countries than in the developing countries whose technological base is narrower and whose economic and financial capacities are much lower than those of advanced countries. The on average smaller size of enterprises, and the relatively more modest research undertakings prevailing in most of the developing countries of Latin-America, only further accentuate the significance of enhancing interactions between the entrepreneurial sector and the research institutions. The barriers between the two sometimes seem to be overwhelming, yet some instances of progress can be mentioned : an institute was created by the University of Buenos Aires (Argentina) with financing from enterprises in areas such as the environment, health, biotechnology; in Chile, a commercial association and professors have been able to improve on the design of a series of products produced locally; and in Mexico, a technical institute addresses quality control aspects of local production. Examples are much more common within and between the developed counties. The Buenos Aires Workshop therefore asserted the critical importance of promoting consistent and systematic ways of sharing experiences and building up new forms of cooperation. A set of Conclusions and Recommendations was agreed on at the Workshop.

In the Latin-American experience it would seem that cooperation between universities and enterprises is guided largely by pure "individual will", and almost as a result of an "instinct of survival" in facing the enormous challenges of economic growth in an increasingly competitive scenario. National players lack information on experiences in other countries and regions, and inter-country clubs or associations of innovative managers are only very slowly taking shape, particularly between the developed and the developing countries, as called for in the Agenda for Development of the United Nations, and the New Partnership for Development adopted in 1992, both of which are currently being implemented.

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Environmentally Sound Technologies : The Interlinkages Between Sustainable Development, Trade and Transfer

Mr. Vladimir Pankov, Division for Science and Technology, UNCTAD

Introduction

The increasingly global character of environmental problems linked with ever urgent problems of sustained development, particularly of developing countries, have brought to the forefront of the international community the concept of sustainable development. The main thrust of such development is stable economic growth, meeting the basic needs of mass population with a minimum burden on environment and without jeopardising the bases for future need satisfaction.

Environmentally sound technologies : A definition

The definition of environmentally sound technologies (ESTs) is a broad one. In general terms, ESTs are technologies, processes and products that prevent or diminish or minimise the impact of economic activities on the environment. According to Agenda 21 adopted at the Conference on Environment and Development in Rio-de-Janeiro in June 1992, "environmentally sound technologies are those that protect the environment, are less polluting, use all resources in a more sustainable manner, recycle more of their wastes and products, and handle residual wastes in a more acceptable manner than technologies for which they are substitutes".

The concept of ESTs is a relative one and depends on the level of scientific and technological knowledge of the community at a specific period of time. Chlorofluorocarbons (CFCs) are a good example of this situation. When CFCs were first used at the beginning of the century, they were considered a safer alternative to toxic substances such as ammonia and sulphur dioxide used at that time and their effects on the ozone layer of the upper atmosphere were not then realised. Thus, their usage became widespread, from refrigeration to numerous other uses such as aerosols and cleaning fluids for electronic components. ESTs can be analysed under two major groups : cleaning technologies and clean(er) technologies. Cleaning technologies consist of the so-called end-of-pipe solutions, to mitigate the hazardous effects of existing processes; clean technologies, incorporate technologies that optimise the existing processes of production by adjusting/ modifying equipment/machines, dosages of inputs leading to diminution of pollution during and after the economic activities. The turnover of the environment industry (mainly for "cleaning technologies") was estimated by OECD to be $200 billion in 1990 and projected to rise to $ 300 billion by the year 2000.

Role of policy measures

Governments in developing countries can play a major role in promoting the transfer of environmentally sound technologies and in building-up the associated indigenous capability. These governments within the means at their disposal should give encouragement to adoption of ESTs by policies that accord them appropriate priority and incentives. It is important that public policies are directed at encouraging internalisation of environmental costs in the activity of economic operators and should take into account economic and social environmental costs for not undertaking or deferring environment-preserving activities as well. Governmental policies need to orient industries towards adoption of pollution prevention, waste minimisation and environmental compliance auditing and adoption of a 'cradle-to-grave' approach for industrial products. It is also the prerequisite of governments to develop a transparent public information policy concerning the environment and support relevant education, training and research programmes in ESTs.

The use of regulatory measures for the widerdiffusion and implementation of ESTs is recommended, though there is a problem of effectiveness of these regulatory tools especially in developing countries mainly because of : weak legal systems, weak power of local fiscal authorities, extent of environmental awareness of public and institutional as well as financial difficulties to monitor numerous small-scale economic agents. The influence of laws and regulations promoting the development and adoption of ESTs by large economic factors is also limited in developing countries. However the use of economic instruments/ measures such as charges on consumption of water, pollution consent fee, grant of subsidies, excise tax on pollution control equipment, depreciation allowance, and soft loans etc. seems to be quite effective. At the same time, in certain cases, these additional charges to promote the generation and use of ESTs are additional constraints to economic growth, especially affecting the poor sectors. Thus the governments of many developing countries generally seem to be unwilling to strengthen environmental standards because of the realisation that enterprises would find it financially nonfeasible to observe them.

Also enforcing of environmental standards in developing countries alone is not adequate to stimulate the generation of clean technologies. The recent global concern and discussions should help developing countries to adopt better environmental standards. In addition, the transfer of ESTs from developed countries should help to improve the capabilities of developing countries to adopt and also generate ESTs.

Analytical information and exchange of experience on ESTs

The dissemination of information on existing and new ESTs to decision makers in developing countries could hasten the application of such technologies and consequently, contribute to furthering a more rapid and successful transfer of technology and strengthening local technological capabilities. Although a wide range of ESTs are often available, sufficient information about them is lacking in most developing countries. Little commonality exists in ESTs applicable to different production or consumer sectors and, within the same sectors, to different geographic areas, and therefore while descriptive and quantitative data on ESTs is readily available, developing countries need analytical and qualitative information to make a judicious selection of ESTs. Various measures, public and private suggested can enhance transparency and reduction of costs of information/ knowledge of ESTs which among others include creation of an international register for new ESTs; disclosure of 'data' on environmental performance of technologies by manufacturers; publicising of information on comparative costs, the terms for transfer of technology and environmental risks; and promotion of private and public institutions providing information on available ESTs. The Rio Conference highlighted the need to develop international clearing houses with linkages to national, sub-regional and international systems, covering broad sectors of the economy such as agriculture, industry and energy.

Endogenous capacity-building

Capacity-building is the most critical factor for technology acquisition, adaptation and generation, in the case of ESTs. The lack of an effective demand and supply link, adequate infrastructure, training and institutional facilities represent an obstacle to the technology absorptive capacity of developing countries. Thus in certain cases technological aid from industrialised countries focuses on capital-intensive hardware, but aspects such as specialised management and maintenance knowhow, together with human resources training are not included in the projects and consequently the facilities often fail to operate at an acceptable level of productivity and sometimes have an adverse impact on the environment and the population, whose traditional means of livelihood are also sometimes affected.

Mechanisms favouring environmentally sound technologies

Other factors hindering the acquisition of ESTs by developing countries are the lack of financial resources to cover increasing expenses in connection with importing or otherwise providing for cleaner technologies. To overcome this, some of the developing countries have explored and sought financial support from international financial agencies, such as the World Bank, while others try to form joint ventures with companies from industrialised countries. Among various options which can be considered the international community to provide additional financing for ESTs, some could be : (i) environmental premiums based on a system of tradeable pollution permits; (ii) international environment offsets; (iii) debt for nature swaps; (iv) bilateral official development assistance; (v) arrangements relaxing limitations on the repatriation of income derived from environmentally sound technology; (vi) tax disincentives to retain the use of environmentally hazardous technologies; (vii) tariff barriers to reduce trade in environmentally hazardous technologies.

ESTs and trade

One of the most important and complex interrelationships between technology and sustainable development relates to the impact of ESTs on world trade patterns. Technological advances in the developed market-economy countries, have varying implications for the present and future competitiveness of developing countries' exports and for the transfer and development of technology. The diffusion of innovations in new key sectors such as biotechnology, in production and use of new materials and computerisation may result in underlining inter-country differences in the existing industrial, scientific and technological base, ability to attract foreign investment and in technology inflows. Such diffusion is also eroding the traditional competitive advantages of most developing countries based on natural resources. UNCTAD documents have also shown that, in view of growing R&D costs and intensified international technological competition, enforcement of intellectual property rights protection is increasingly sought. Related considerations, including possibility of exploiting economies of scale and complementarities in

R&D, have led companies particularly in developed market-economy countries, to forge strategic alliances with competitors, consumers and suppliers, mostly in other developed countries. Such trends are also likely to affect acquisition and generation of ESTs, and their application in areas in which they could have a positive impact on the competitiveness and advancement of developing countries.

Promising areas of ESTs application

In view of the developing countries' dependence on the agro-industrial sector and on raw materials which make up the bulk of their export revenues, efforts directed towards applying and developing environmentally-friendly technologies for agricultural production and processing are critical to these countries. The use of alternative agricultural practices, biofertilisers and pesticides, genetic engineering etc. offer promising opportunities. Nevertheless these still require monitoring with respect to intellectual property protection and the longer-term effects on the eco-system. The other area for ESTs application is the activities associated with intensive use of energy which are the major source of greenhouse gases (GHG) responsible for global warming. There is thus a need for technologies which aim at reducing the emissions of GHGs or recapturing them at the source. A variety of technical opportunities exist for reducing the fossil fuel intensity of industry or replacing such fuels with other sources of energy. In general, renewable energy technologies, especially solar energy technologies and biomass, offer real advantages as a greenhouse gas mitigation option. Biomass in the form of fuel wood is the primary energy source for almost half of the world. While most developing countries possess substantial biomass reserves, the use of fuelwood in many cases poses a serious threat to the environment, underlining the importance of new techniques and of improving upon existing technologies for a more rational and efficient use of renewable energy resources.

In-depth work and the exchange of experiences is necessary to identify and assess areas and sectors in which ESTs can make a significant contribution to developing countries' competitiveness and development and at the same time assist in policy and decision making.

Global Environmental Negotiations and EST

Recent global environmental negotiations and agreements in diverse specific fields have raised a whole set of issues relating to environmentally sound technologies. The aim is to basically discourage or forbid the use of environmentally hazardous products and technology and promote common efforts to facilitate access to environmentally safe alternative substances and technologies. The developing countries are emphasising the financial aspects of transfer of ESTs at international fora/conventions. Certain provisions relating to technology coooperation and transfer of ESTs are contained in the 1979 Convention on Long-Range Transboundary Air Pollution, the London Amendment of the Montreal Protocol for the protection of the ozone layer, the Global Environment Facility (GEF) and the Earth Summit at Rio.

Multi-Country and Multi-Enterprise Partnership in Technological Research and Commercialisation

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Introduction

A nation's economic prosperity and sustainability are to a large extent linked to its technological development and infrastructure. In view of the emerging new global order of technological competitiveness, a coordinated, inter-nations approach at least within the Asian and Pacific region is needed to increase the effectiveness of technology development infrastructure by providing a focused approach based on diverse experiences of nations of the region.

ASEAN and EC experiences of multicountry cooperation

ASEAN and the EC are good examples of instruments of regional cooperation for achieving economic and industrial prosperity. The ASEAN region countries have a reasonably strong manufacturing infrastructure and skilled labour bases and thus extend inter-country cooperation into diverse areas including S&T. The ASEAN Cooperation Unity (ACU) was formed with the responsibility for programming, planning and management of ASEAN technical and economic cooperation.

Similarly in order to meet the economic challenge of USA and the countries of the Pacific basin and to improve the competitiveness of European industries, the European Technology Community has been established. It envisages inter-alia cooperation between member countries in the area of S&T, of particular importance being the concept of cost-sharing of contract research which has proved to be an effective instrument to encourage collaboration between industries/companies located in different member states.

There is thus a strong need, and potential for multi-country and multi-enterprise partnerships among the countries of the Asian and Pacific region to bring about economic growth and prosperity for the participating countries. A Working Group could be formed with representatives from participating member countries to the Workshop which could formulate long term pre-competitive research programmes that fit into well defined strategies of member countries. As these programmes are close to the market place and thereby involve less risk and uncertainty, the major portion of financing for them should be derived from industry. Ideally a bottom-up and top-down approach should be adopted for formulation and implementation of these programmes among the member countries.

S&T in Malaysia

The National Council for Scientific Research Development is responsible for promoting the use of science and technology and for establishing a sound technological base for industrialisation. In the country's Sixth Plan, a total of RM 588 million has been allocated to the Intensification of Research In Priority Areas (IRPA) programme for five major sectors viz. agriculture, industry, medical, strategic and social science. A major concern in Malaysia is that public sector R&D should become more commercially relevant and contribute towards the economic development of the country. Public sector research institutes are thus encouraged to undertake applied research to solve product and process-related problems of industry though they would also continue to undertake government-funded strategic industrial and non-industrial research. While partnership between research institutes and industry is critical to ensure the relevance and usefulness of public sector R&D, commercialisation of the results of these institutes would be the capstone of achievement thereby providing a return on investment of time, finances and labour.

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An Overview of Present S&T System in Pakistan

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Introduction

At the time of independence in 1947, Pakistan inherited a poor infrastructure for S&T research and education. However, in the last 47 years, it has gradually built up the S&T infrastructure in the country.

National commission for science and technology

A National Commission for Science and Technology (NCST) has been established in Pakistan with a current membership of 28 comprising ministers, scientists, academicians etc. The Commission has an Executive Committee (ECNCST) headed by the Finance Minister with functions that include consideration of all matters pertaining to S & T and coordination, implementation, evaluation of S&T/ R&D policies/ programmes initiated by various ministries/ divisions of the federal government and S&T organisations/ R&D institutions etc.

The government recognising the importance of Science and Technology in the overall national development established in 1972 an independent Ministry of Science and Technology. The Ministry presently has two important autonomous organisations, viz. the Pakistan Council of Science and Technology, an advisory body to the government and the Pakistan Science Foundation, primarily a financing agency to promote basic and fundamental research.

In addition to these agencies, the country has a fairly large number of S&T institutions besides universities. The S&T institutions in the country can be broadly placed in four distinct categories:

i. Institutions under the Ministry of Science and Technology

Presently, there are twelve institutions with activities ranging from high-tech areas of research to mundane fields of socio-economic services.

ii. Institutions under other ministries

These include Pakistan Space and Upper Atmosphere Research Commission (SUPARCO) under the Cabinet Secretariat; Defence Science and Technology Organisation(DESTO), under the Ministry of Defence; Pakistan Agricultural Research Council (PARC) under the Ministry of Food and Agriculture.

iii. Provincial institutions

These are under the purview of provincial governments and are primarily concerned with traditional areas like agriculture, animal husbandry, public health and irrigation forestry.

iv. Universities

These are under the University Grants Commission with two-fold activities of teaching and research.

National standing committees in S&T

Rapid changes in science and technology in the world have made it incumbent for all developing countries, including Pakistan, to develop a basic capability in new and emerging technologies to understand the new developments and changes. The NCST has accordingly established 10 Standing Committees in specific areas of electronics, biotechnology and genetic engineering, oceanography, upper atmosphere and space, national conservation and environment, renewable energy, new materials, informatics, Laser and fibre optics.

Industrial R&D organisations

The share of R&D activity in Pakistan within the industrial sector is comparatively much lower than in the government R&D organisations. Research on products and processes has by and large been neglected. Large private and public sector industries prefer imported technologies, while small companies do not have the finance to risk on technologies/ products emanating from indigenous R&D. The technology transfer mechanisms adopted by industry thus have not helped to create demand for indigenous research and development. The latter, in turn, have often neglected to establish close ties with industry to promote a flow of knowledge either way. It is a matter of great concern and regret that Pakistani industry has not fully realised the potential and merit of indigenous research and development efforts. Very few production or manufacturing units utilise the indigenous R&D results. This has resulted on one hand in the non-utilisation of indigenous R&D and on the other hand, the processes, products and techniques developed becoming outdated and incompetitive in domestic and international markets.

Technical support services

Technical Support Services in Pakistan include the scientific and technological statistics service of PCST, software development specialist organisations, scientific equipment manufacturing and maintenance services offered by the Swiss Training Centre of PCSIR at Karachi and engineering and management consultancy services for which a Consultancy Promotion and Development Programme (CPDP) is underway. In 1987 a Scientific and Technological Development Corporation of Pakistan (STEDEC), a private limited company was established to bridge the wide gap between the national R&D organisations and the end users of research results. It acts as front office for the commercialisation of projects and technologies emanating from R&D organisations under the Ministry of Science and Technology and various other ministries.

Constraints and issues concerning S&T system

Though science and technology has in recent years attracted relatively greater attention and funds yet these have been inadequate and therefore much remains to be done. Major constraints experienced are: thin spread of limited available resources resulting in sub-optimal efforts; isolation of the system from economic and development planning; poor quality of science education in schools and universities; industry's preference for foreign sources of technology and expertise etc.

National technology policy

The national technology policy has the objective :

i. to bridge the gap between the best local and the best international practices in industrial technology;

ii. to bridge the gap between the best and sub-standard local practices in industrial technology;

iii. to improve and develop technology to enhance international competitiveness in the long run; and

iv. to develop human resources.

Instruments of national technology policy

The National Technology Policy envisages a leading role for the private sector with selective government interventions aimed at correcting market failures and imperfections. A guiding principle of this policy is to promote environmentally sound and sustainable technologies. To implement the strategies of the Technology Policy some of the instruments include :

(a) Liberal regime for technology transfer and means to attract foreign investment;

(b) Rationalising the R&D system by reorganising the publicly funded R&D organisations and relating their programmes directly to the needs of Pakistan industry;

(c) Allocating 2 per cent of GNP for R&D by year 2000;

(d) Strengthening industrial infrastructure by establishing a suitable number of incubation centres and industrial extension services/ centres especially for SMEs;

(e) Strengthening metrology, standards, testing and quality (MSTQ) system to and providing incentives to manufacturers to improve product quality;

(f) Dissemination of techno-commercial information;

(g) Encouraging venture capital funds to finance innovative and technology-intensive projects;

(h) Evolving trade and tax policies to maximise indigenous technology development and exploitation;

(i) Improving legal frame work for protection of intellectual property rights.

Major Aspects Concerning Environmentally Sound Technologies (ESTs) within the Framework of UNCTAD, Including Elements for Possible New Initiatives

Mr. Vladimir Pankov, Division for Science and Technology, UNCTAD

Introduction

There are various issues related to the transfer of environmentally sound technologies (ESTs) to developing countries. Economic development as an ecologically sustainable activity is today recognised as a critical social goal in both industrialised and developing countries. The concept of sustainable development has brought together developmental and environmental concerns and the role of technology in combatting numerous environment-related problems facing developing countries. In order to face these challenges, developing countries are seeking adoption of new economic and technological policies which include wider use of ESTs.

Though some ESTs are available in developing countries, the majority of the clean processes originate in the industrialised world and developing countries can avail of these technologies through transfer and adaptation. However the transfer of ESTs is not an end in itself and there are a number of associated issues that need special attention such as terms and conditions and modalities of transfer of ESTs as well as coherent national polices to create and strengthen endogenous technological capacity to use, master, develop and generate clean technologies. UNCTAD and the United Nations Conference on Environment and Development, Conference in Rio, have emphasised that ESTs are an essential component of a successful strategy for sustainable development. Thus there is a need to examine in detail the various aspects such as development of ESTs, information on state-of-art technologies, access to and transfer of ESTs, building of endogenous capacity etc. UNCTAD and the government of Norway organised, in October 1993 in Oslo, a Workshop on the transfer and development of ESTs to developing countries.

Discussions of ESTs at the Oslo Workshop

The Workshop's aim was to analyse the issues involved in the generation, transfer, diffusion and financing of ESTs to developing countries and to discuss policies and measures to promote the same. It emphasised that environmental needs varied from country to country and ESTs transferred from one country to another were not expected to perform in the same way. The private sector had to play an increasing role in the development and dissemination of ESTs. It was recognised that the involvement of TNCs in developing countries' economies could provide an opportunity for transfer of ESTs and spreading environmental awareness and higher environmental standards. However it was emphasised that in all cases, developmental needs would require solutions compatible with the sustainable use of the environment/ resources and this should form the basis of the design and adoption of environmental incentives and regulatory measures by any country. The role of governments in setting the context for technical development was important especially in providing the appropriate regulatory framework, supportive infrastructure and effective incentives to stimulate demand for environmentally sound technologies. The Workshop recommended that while evolving such measures, special problems of SMEs should not be neglected. SMEs in developing countries faced particular constraints with regard to information, expertise and finance for upgrading environmental standards. Therefore measures such as tax refunds and support for research and development (R&D) were of particular importance. It was recognised that the issue of financial resources was among the major problems in development and transfer of ESTs and therefore it was felt that ODA should increasingly support financial measures and activities relating to environment protection and strengthening environmentally sound development. The Workshop also deliberated on the impact of intellectual property rights (IPR) on transfer and development of ESTs. It was felt that the problem of IPR was not of primary importance, particularly given the fact that not all proprietary technology was in private hands. However small inventors who lacked the financial resources of large corporations faced the biggest constraints when acquiring proprietary rights.

In order to achieve and diffuse environmentally sound practices the Workshop recommended that environmental awareness should become a part of the business culture. Also local capabilities for sustainable development should be integrated with the broader agenda for sound economic growth and structural change in developing countries.

New initiatives/actions

The Workshop endeavoured to find innovative approaches that would enhance the process of transfer and development of ESTs. Some initiatives suggested include extending national efforts upwards to the bilateral and multilateral levels between countries as well as downwards to the local level; strengthening of South-South cooperation particularly where environmental problems have a clear subregional and regional dimension; creating awareness/ information on ESTs; training of people; documenting existing facilities within both national and international environmental bodies/ agencies; benchmarking to encourage best practice standards in ESTs at the firm level, and mobilising funds to provide incentives for helping the private sector to undertake technologies initiatives.

The Workshop recognised that the absence or weakness of effective regulatory structures and enforcement mechanisms in developing countries presented a major obstacle to the introduction of ESTs. It was suggested that priority should be given to starting the process by designing at least minimally effective, simple regulative systems and then moving on to the gradual development of more effective measures over time. The Workshop recommended that the reform measures undertaken by many developing countries in other sectors of the economy need to be extended to the important area of government R&D activities, where a refocus on improving the commercialisation of environmental technologies was needed.

Diversity of Experiences and Possibility of Furthering Multicountry and Multi-Enterprise Partnerships - Indian Experience

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Introduction

Two of the diverse factors which affect the cooperation between the R&D community and the enterprises, have a major bearing on the Indian context. The first factor is the lack of industrial competition hitherto due to the Industrial Licensing System, that made the Indian industry uncompetitive and technologically obsolescent and the second factor is the large proportion of research (around 75 per cent) carried out in public funded R&D institutions, that is away from the place of its utilisation. The need for developing an interaction mechanism between the public funded R&D institutions and industry is vital for the successful commercialisation of R&D results and NRDC has been created to fulfill this need.

Till recently the public funded R&D institutions were obliged to license their technologies through NRDC. However after 1988, the R&D institutions are permitted to market their technologies on their own. NRDC, thus has to survive in a competitive market. It is now offering more comprehensive technology transfer services than earlier and these include : market surveys, technology evaluation and assessment assistance, feasibility and design reports and on the financial side providing interest free loans, equity participation to the extent of 50 per cent, assistance in arranging for finances from venture capital funds etc. This has improved NRDC's performance substantially; profits have increased 30 times and export earnings have increased to US $ 0.5 million/ annum from nil in 1986.

Initiatives by NRDC for technology diffusion

One of the recent initiatives successfully carried out by NRDC is the 'mother licensee' arrangement for enterprise to enterprise cooperation in technology diffusion. A good example is the Rice Husk Particle Board technology developed at the Indian Plywood Industries Research Institute and licensed to

M/s Padmavathy Panel Boards Ltd., Bangalore (the mother licensee) by NRDC for setting up a 600 TPA pilot plant. After the technology was successfully implemented, it was licensed to six more companies in India. These licensees were given the complete technology on a plant to plant basis with in-plant training at the 'mother licensee's' plant. In turn, the 'mother licensee' was compensated suitably by way of a share in royalties from subsequent licensees. A plant is now being set up in Malaysia and through the efforts of APCTT negotiations are on for two plants in China as well.

An other initiative of NRDC for furthering the promotion of Indian technology abroad, is the scheme for financial and technical assistance for patenting not only knowhow but products as well. NRDC arranged for and provided 50 per cent of the cost of foreign patenting. In turn industry would pay to NRDC a royalty of between 2.5 and 5 per cent on the export value of the products exported to countries where the patents were held.

NRDC has also introduced a Small and Medium Industries Innovation Programme, the main objective of which is to encourage small and medium scale industries to generate new products/ processes and promote their commercialisation. The programme is to be implemented in three phases:

Phase I : NRDC invites proposals on innovative ideas from small and medium scale industries out of which 60 proposals are selected for an award of Rs. 50,000/- each in the first year. The awardees are given 12 months time to convert their ideas into a new technology/product.

Phase II : A High Powered Committee selects 10 projects for Phase II awards of Rs. 500,000 each for larger developmental efforts.

Phase III : The awardees are encouraged and assisted to seek venture capital or normal financial assistance for commercialisation of technology/product. NRDC could also provide financial assistance to implement project commercially.

ADOPTION OF RECOMMENDATIONS

The concluding session was chaired by Dr. Nilyardi Kahar, Head R&D Centre for Metallurgy, Indonesian Institute of Sciences, Indonesia. Dr. J. Bischoff summarised at length the various papers presented during the workshop and placed and draft recommendations for discussion and consideration of the participants. The recommendations were discussed at length and some were modified/amended. The recommendations finally arrived at and adopted are given in the text as part of the Executive Summary.

The workshop ended with a vote of thanks by Ms. A. Von Wartensleben.

Asia-Pacific Regional Workshop On R&D Community - Enterprise Cooperation In Technological Research and Commercialisation/Application of Results

7-10 November 1994, New Delhi, India

Programme

Monday, 7 November 1994

Inauguration

1100 - 1215 hrs	Inauguration of the workshop at UNDP Auditorium, 55 Lodi Estate, New Delhi - 110 003
1345 -1400 hrs	Registration at APCTT Conference Hall

Technical Sessions - APCTT Auditorium

1400 -1415 hrs	Keynote address by Ms. Aurelie von Wartensleben, Senior Economic Affairs Officer, Division for Economic Cooperation among Developing Countries, UNCTAD

Technical Session I

Factors influencing the performance of R&D organizations

1415 -1445 hrs	Introduction of theme by - Ms. Aurelie von Wartensleben, Senior Economic Affairs Officer, Division for Economic Cooperation among Developing Countries, UNCTAD
1445 -1515 hrs	Dr. Nilyardi Kahar, Head, R&D Centre for Metallurgy, Indonesian Institute of Science (LIPI) Indonesia
1515 -1530 hrs	Tea Break

1530 -1600 hrs	Dr. Won Ki Kwon, Professor, Pohang University of Science and Technology, Korea
1600 -1630 hrs	Dr. Dilli Devi Shakya, Executive Director, Research Centre for Applied Science and Technology Tribhuvan University, Nepal
1630 -1700 hrs	Dr. H.R. Bhojwani, Head, Technology Utilization Division, Council of Scientific & Industrial Research,India
1700 -1730 hrs	View points of enterprises and discussions

Tuesday, 8 November 1994

Technical Session II

Special aspects and issues concerning application or commercialization of R&D results in selected areas

0900 - 0930 hrs	Keynote address by Dr. Ashok Jain, Director, National Institute of Science, Technology and Development Studies, Council of Scientific & Industrial Research, India
0930 -1000 hrs	Mr. Aziz A. Khan, Managing Director, Scientific & Technological Development Corporation of Pakistan (STEDEC), Pakistan
1000 -1030 hrs	Mr. Md. Abdul Matin, Director, Pilot Plant & Process Development Centre, Bangladesh Council of Scientific and Industrial Research, Bangladesh
1030 -1100 hrs	Presentations on selected sectors
-	Mr. Dieter Koenig, Scientific Affairs Officer, Division for Science and Technology, UNCTAD
-	Dr. M. Chakraborty, Deputy Director, Central Glass & Ceramic Research Institute, India

1100 -1115 hrs	Tea Break
1115 -1215 hrs -	Dr. R.Narayan Iyengar, Director, Central Building Research Institute, Rookree, India Dr. V. Prakash, Director, Central Food Technological Research Institute (CFTRI), Mysore, India
1215 -1245 hrs	Mr. Sun Jianxin, Deputy Director, China Technology Market Management and Promotion Centre (Sinotechmart)
1245 -1315 hrs	Lunch Break
1315 -1700 hrs	Visit to Central Electronics Limited, Sahibabad, U.P.

Wednesday, 9 November 1994

Technical Session III

Encouraging the Increased Utilization of Locally Available R&D Options

1000 -1030 hrs	Keynote address by Dr. Dal-Hwan Lee, Principal Researcher, Science and Technology Policy Research Institute, Korea Institute of Science and Technology, Korea
1030 -1100 hrs	Dr. V.V. Subba Rao, Joint Adviser Department of Scientific and Industrial Research, India
1100 -1115 hrs	Tea Break
1115 -1145 hrs	Mr. Zhao Chunshan, Deputy Director General, The State Science and Technology Commission (SSTC), China
1145 -1215 hrs	Dr. Nandanie Daya Ediriweera, Head, Agro & Food Technology Division, Ceylon Institute of Scientific & Industrial Research, Sri Lanka

1215 -1245 hrs	Mr. Cao Minh Kiem, Chief of R&D Information National Centre of Science and Technology Information and Documentation, Vietnam
1245 -1315 hrs	View points of enterprises and discussions
1315 -1415 hrs	Lunch Break
1415 -1715 hrs	Field visit

Thursday, 10 November 1994

Technical Session IV

Diversity of experiences and possibilities of furthering multicountry and multienterprise partnerships

1000 -1015 hrs	Introduction of theme by Ms. Aurelie von Wartensleben, Senior Economic Affairs Officer, Division for Economic Cooperation among Developing Countries, UNCTAD
1015 - 1030 hrs	Mr. Vladimir Pankov, Division for Science and Technology, UNCTAD.
1030 -1100 hrs	Dr. Mustaza Hj. Ahmadun, Head of Materials Technology Centre, Standards and Industrial Research Institute of Malaysia (SIRIM), Malaysia
1100 -1115 hrs	Tea Break
1115 -1145 hrs	Dr. S.M. Junaid Zaidi, Chief , Pakistan Council for Science and Technology, Ministry of Science and Technology, Pakistan
1145 -1215 hrs	Mr. Vladimir Pankov, Division for Science and Technology, UNCTAD
1215 -1245 hrs	Mr. N.K. Sharma, Managing Director, National Research Development Corporation, India

1245 -1315 hrs	View points of enterprises and discussions
1315 -1415 hrs	Lunch Break

Concluding Session

1415 -1600 hrs	Draft recommendations : Discussions
1600 -1615 hrs	Tea
1615 -1700 hrs	Adoption of recommendations

List of Participants

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