An Analytical Study on Problems and Issues of

TRANSFER OF SCIENTIFIC RESEARCH RESULTS TO THE PRODUCTION SECTOR

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Islamic Educational, Scientific and Cultural Organization
(ISESCO)
1421H / 2001

Published by
the Islamic Educational, Scientific and Cultural Organization (ISESCO)
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Typesetting and design at
Photocomposition Unit - ISESCO

Legal number: 328/2001
ISBN 9981-26-272-2

Printing: **Imprimerie Fadela**
Mohammedia - Kingdom of Morocco

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FOREWORD

The power to achieve self-sustained socio-economic progress by the developing countries, to a great extent, lies in their capacity to utilize the scientific research results and innovations into new products, processes or industries. This capacity not only helps in creation and upgrading of indigenous technologies, but also helps to exploit scientific research results or to acquire, develop, diffuse and manage technologies available abroad for their economic benefits.

The Islamic Educational, Scientific and Cultural Organization (ISESCO) has always accorded a high priority to those programmes which have direct bearing on the socio-economic development of the Member States. Under Science programmes, various activities are conducted to promote university-industry interaction in order to develop necessary support systems leading to technological innovations. Efforts are made to identify and tackle various obstacles being faced by the research institutions or university laboratories for technological innovation of their industries. The present “Analytical Study on Problems and Issues of Transfer of Scientific Research Results to the Production Sector” is a small step in this direction.

The Study has been prepared by Dr. S. M. Junaid Zaidi, Director, Commission on Science and Technology for Sustainable Development in the South (COMSATS)- Institute of Information Technology (CIIT) and Mr. Tahir Naeem, Project Manager, Private Power and Infrastructure Board (PPIB), Islamabad, Islamic Republic of Pakistan. The Study provides a closer look and in-depth examination of the complex issues in the transfer of the scientific research results and suggests various measures in strengthening the necessary supportive system to facilitate university-industry interaction process. Recommendations to governments, policy-makers, research and development institutions, industry and entrepreneurs are also given. ISESCO is grateful to the experts for the efforts they exerted in the preparation of the present Study.

It is hoped that the Study will provide useful information in successful utilization of scientific innovations and new technologies and will guide especially the scientists and researchers in universities and research centers, government officials, decision-makers, science and technology policy-makers and entrepreneurs in establishing a productive and meaningful linkage between universities and industries to utilize it for the economic benefits.

Dr. Abdulaziz Othman Altwaijri

Director General
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SYNOPSIS

In development planning, an important place has been accorded to the concept of self-reliance in developing countries, and in that perspective, the need for capacity creation in science and technology (S&T) has generally been underscored by national and international bodies. Political commitment of almost highest order has been given to S&T organizational infrastructure and broad policy objectives, with the expectation that it would be instrumental in attaining the development tasks and national priorities. At the micro-level, S&T development programs and projects in different areas such as agriculture, health, industry, etc. have been undertaken with a view to technology development. Considerable attention is being given to the tasks at the technology generation level, such as development of human resources and qualified S&T manpower; R&D allocations and S&T institutions, etc. However, various problems, constraints and issues that arise at the level of technology commercialization and transfer of scientific research to the production sector have not been subjected to any systematic and in-depth analysis.

Technology utilization and their marketing are faced with several problems, constraints and limitations in Muslim countries. Utilization of research results is unsatisfactory and technologies generated are not used optimally. There is a deficiency of pilot plants and demonstration effects; linkage between industry and R&D institutions are not very effective. The transfer of skills to the production sector is not adequate and technical assistance required for the sake of commercializing technologies is not requisite. Furthermore, there is dearth of risk capital, and technologies generated indigenously are not mature and proven, and in many cases have, to compete with those being imported. Moreover, data and information regarding the nature of R&D results do not receive due publicity so as to be picked up by the potential end users. There is earnest need for effective and improved channels and mechanisms for diffusion of the technologies generated indigenously.

The need for evolving and strengthening institutional mechanisms, promotional activities and organizations for the sake of transfer of scientific research results to the production sector is practically of a continual nature in varied development stages. There is a need to develop a mechanism for obtaining of risk capital for technology development projects, starting from applied research stage; to improve all environments for private R&D in fundamental technologies and to promote research exchange among industry, R&D institutions and universities. Need for such tripartite collaborations in Muslim countries are greater and appropriate measures also need be taken in this respect.

Technology being transferred has to be mature and proven; otherwise, commercial interest is bound to be insufficient. In any case, there would be lack of credibility and of acceptability of research results unless these are utilizable by the industry. It is here that the role of venture capital and of risk coverage comes. Making risk capital available for implementations of technology utilization and development program is very crucial in giving impetus to the use of indigenously developed products and processes. Another dimension of this problem is possible lack of venture capital to promote commercialization of unproven technologies. In this respect, the crucial significance of the role of the development financing and risk banking agencies must be underscored by necessary political commitment.

Pitfalls and difficulties in the successful transfer of scientific research results to production sector owe a great deal to a propitious environment for technology development, inspired by spirit of competitiveness, and result and market oriented industrial ethos in generating technologies. It is basically a problem of R&D and technology transfer management, which has to be, viewed in light of the fact that larger involvement and greater place must be accorded to the private sector in the process of industrialization. A major task for the government is to create and sustain stimulating, competitive environment.

An important modality regarding the government role is that it should be directional, providing adequate set of incentives and promotional support services. Government as a public entity can play the role of catalyst more effectively. In the past, in most of the Muslim countries, the government, in assuming the role of business and industry, has not delivered the goods in a manner comparable to industry's role.

The mere promotion of R&D activity in quantitative terms is not enough. Research activities should be successfully accomplished and be, in the final analysis, marketable. Attempts at the generation of technologies are necessary and important. But they cannot bear fruit without the optimal utilization of technologies generated by the production sector. Successful commercialization of technologies can be a useful indicator of the technology development, in as much as it is a necessary complement to the exercise of technology generation. Therefore, importance has to be attached to technology utilization and commercialization of research results as an instrument for strengthening technological capabilities so that it can be instrumental in accelerating the technological and social transformation and attaining the objectives of self-reliance.

1 BACKGROUND

The development of science and technology (S&T) is closely linked to important national objectives in areas such as economic growth, health care, national security and environmental protection. These linkages implicitly raise the question of what goals the nation should have for S&T. Despite the increasing internationalization of S&T, the linkages between a nation's internal scientific and technological capabilities and its well-being will continue to be strong. The countries that best integrate the generation of new knowledge with the use of that knowledge will be positioned to be leaders of the 21st century.

Each component of the S&T system and its intended role is important. Today's world is faced with many problems, the solutions of which will depend on the knowledge generated by research. The scientific research carried out in universities and various special laboratories will continue providing new knowledge and trained personnel. Equally important is that research results are transformed through process of engineering into new technologies. This process requires an economic, managerial and legal environment that fosters innovation and the adoption of new technologies. In today's world, the government is a partner with industry in identifying and developing technologies essential for national needs.

To start with, research and development (R&D) efforts are to be devoted to the assimilation of imported technologies; these may be reduced, over a period of time to allow diversion of some resources to R&D efforts directed towards improving traditional technologies and producing new technologies. In other words there will be a time lag in a country's becoming competitive vis-a-vis. the international market and the time when assimilation of imported technologies were started. This assimilation of imported technologies will allow some abandonment of efforts in a number of activities related to the innovation chain, e.g. the basic and applied research, prototype development, etc. However, once the country reaches a stage where the production standards become consistent, certain protective incentives need to be revised and conditions made more stringent, so as to compel the producers to respond to the competition in the international market.

The indigenous technologies need not and should not be ignored in the initial phase of technological restructuring. Rather, it is advantageous that, in a few selected sectors where the factor endowments (the natural resources, manpower requirements, and availability of local demand) permit, incentives should be provided to the development of indigenous technologies. The linchpin is that such incentives need to be revised every now and then, so as to compel the industry to respond to the changing environment.

2 POLICY FRAMEWORK AND INSTITUTIONAL MECHANISM

In the past two decades, developing countries have been faced with the imperative challenge of establishing policies at the national level to support the process of innovation. Modernizing the productive infrastructure requires the creation of an appropriate policy-environment (within the framework of international economic relations and the trading systems) to stimulate productivity, competitiveness and the effective absorption and diffusion of new technologies. The developing countries are in the process of enhancing the interaction between the public and private sectors and are in pursuit of increasing cooperation among different economic activities, in such a way as to favour integrated technological progress and innovation at the macro and micro levels.

2.1. Orientation and Framework of Policies

The policies governing utilization of indigenous technologies also flow from the aims, objectives, functions and responsibilities of the institutional mechanism and various promotional organizations that have been established for promoting utilization of indigenous technologies. Often promotional schemes and regimes of incentives have been provided for encouraging industry to generate and utilize indigenous technologies. Furthermore, regimes of intellectual property rights in various developing countries safeguard the rights of the technology generators. The administration of intellectual property rights has also the goal of promoting utilization of indigenous technologies, through affording rewards for the innovation.

At the outset, it would not be sufficient that a country makes any choice that is too broad to allow the concentration of efforts and resources. For example, if a country opts for selectivity in industrialization in a few strategically important industries, as against a general preference for efforts in the manufacturing sector, it would be more advantageous. The other important criteria in fixing this borderline is that a country needs to be inward-looking in some areas i.e. local technology for the local market and outward-looking in some other areas i.e. improved technology (local or imported and assimilated) for the international market. Another strategy practiced by the early-developers in their initial phases of development has been import-substitution. However, it has been observed that import-substitution, coupled with protection against the international competition is not healthy in the long run. Therefore, if a country extends enough protection to the local industry in a certain sector, the subsidies need to be withdrawn gradually. The government's intervention, in itself, should be a dynamic process and should always be subject to revision and modification.

There has often been a debate whether the governments need to be a mere facilitator, as had been the case of the early developers, or it should adopt an interventionist approach. Experience has shown that, for economies where the markets cannot take care of their own and the (input) prices are highly distorted, state intervention is essential to ensure access of resources to all concerned. Experience is further suggestive of the fact that, before a country acquires a degree of technological independence, it has to undergo a long period of dependence on the imported technology. Concerted efforts to adapt, assimilate and indigenise the imported technology call for the allocation of efforts and resources in a planned and judicious manner, which, in turn, calls for a policy intervention by the government.

Japan : A successful integration of judicious technology-importation and indigenization efforts in the Asian region is demonstrated by the case history of Japan. The Japanese approach to indigenous technology development demonstrates how absorption, assimilation and adaptation of technologies (acquired from abroad) could in continuum prepare the ground for building up indigenous technological capabilities. The Government of Japan, through the Ministry of International Trade and Industry (MITI), had been instrumental in initiating efforts to promote research through funding of specific programmes and establishment of institutes in specific disciplines that work in close cooperation with universities and industry. The collaborative research was promoted through the institution of sub-contracting or keiretsu, as popularly known. The tremendous growth of auto parts, textiles and software industries owes much to keiretsu relationships among various technology-support institutions.

After the initial phase of adopting this followers' strategy was over, there was a need to move to the leader strategy. Then, the Government started funding large, even risky projects, such as development of high-performance computers and power-generators through research associations. Some of the recent efforts in this respect include establishment of the Research and Development Programme on Basic Technologies for Future Industries, administered by the Japan Key Technology Centre. This Programme, launched by MITI, partially finances government-business-academic cooperation. There are different national technical institutions, administered by the Agency of Industrial Science and Technology (AIST) under MITI. They are engaged in R&D, promote joint R&D with universities and private firms, and often organize technology-research associations. MITI has also identified about fifty locations for the development of 'technology-parks' for future industries. The New Energy and Industrial Technology Development Organization (NEDO), a public organization pursuing basic and advanced R&D in industrial technology, has built up large-scale facilities, with the private sector, and conducts international joint research.

Korea : The Republic of Korea (ROK) has emphasized the technology acquisition and development under the imperatives of modernization. Research and development efforts are of relatively recent origin in the ROK but, due to the momentum and success gained in the recent decades, the country is laying emphasis on promoting (i) in-house R&D in the private sector, and (ii) national R&D projects in collaboration with industry.

The Ministry of Science and Technology of the ROK initiated programmes of cooperative R&D for the rapid utilization of the research results in government-sponsored research institutes. Various schemes and incentives were devised to promote cooperative programmes between government research institutes and industry. Under the cooperative research programmes, new technologies were acquired by private firms, in collaboration with the government research institutes. Concerted efforts in the assimilation of imported technologies have led to successful adaptation of these, thereby increasing the chances of better utilization. The most important advantage for industry in establishing such types of vertical linkages with the research institutes is the enhancement of technological capabilities, as against the access to certain markets in case of conventional horizontal linkages with the suppliers of technology.

The different strategies for development being pursued in various countries have been the driving force in setting priorities for utilization of results of indigenous research. Development strategies, such as "growth led export" in India, "demand-pull" approach in the Philippines, technology-led development in the ROK (as referred to earlier), export-promotion strategies in Pakistan, etc. are but a few examples of these.

2.2. Institutional Mechanisms and Promotional Organization in Various Countries

A number of countries have experimented with various mechanisms for facilitating inter and intra-country transfer of technology. At the outset, however, it would be appropriate to appreciate that there is no single mechanism that is suitable under all conditions. The government may play either an interventionist role or a facilitating one; the approach may be administrative, legislative or simply political. The different strategies and approaches adopted by various countries during the preceding decades all seem to loose vitality rapidly. The problem is further complicated by the wide variety of technologies to be transferred in different sectors of economy, such as industry, agriculture, mining, construction, etc.

The developing countries seem, more or less, convinced that an interventionist approach would be required, at least in the initial short run, to provide strategic guidance and foster a climate conducive for innovation and its promotion. Most of the developing countries have established institutions specializing in S&T activities. Two major groups of institutions that have since emerged are:

a) Institutions charged with the responsibility of formulating and coordinating S&T policy. Typically, these included Ministries of Science and Technology, Commissions for S&T and S&T Councils, Office of the Technology Assistant, etc.

b) R&D institutions set up to serve specific sectors of the economy, starting with agriculture, industry, health, water, energy, construction, mining, etc.

Such institutions have been set-up primarily to give an overt (and sometimes a tacit) S&T policy to the country. Efforts have been aimed at enhancing productivity of R&D, joint efforts among R&D institutions, universities and industry, for implementing selective projects and programmes. The objectives usually include localizing key industrial-technologies, by strengthening indigenous R&D capabilities and introducing advanced technology from abroad for upgrading national technological capabilities.

Korea : The S&T policies of the ROK have sought to transform the economy from being labour-intensive to a more viable technology-intensive one and aim at making it knowledge-intensive. It is realized that, in view of country's limited resource-endowments, increased productivity through technological innovation and improved efficiency is essential for ensuring rapid economic growth.

Several policy and legal measures manifest the government's basic commitment to development as well as utilization of indigenous technology. The Science and Technology Promotion Law provided the government's basic commitment to policy. In addition, a series of fundamental laws were enacted to support the implementation of technological development:

- Technical Development Encouragement Law of 1973, which supports private and public corporate enterprises through tax privileges and other incentives;
- Engineering Services Promotion Law of 1973, which ensures the quality-performance of professional engineers;
- National Technical Qualification Law of 1973, which, through examinations and certifications, regularizes the professional status of engineers and technicians.
- Assistance Law for Designated Research Organization of 1973 provides incentives (in legal, financial and fiscal terms) for research institutes in specialized fields where the government and private industry place particular emphasis, such as ship-building, electronics, communication, mechanical and material engineering, and energy and related areas;
- Law for the Korean Science and Engineering Foundation of 1976 provides a legal basis for the establishment of the Foundation to act as a prime agent for strengthening research in basic and applied sciences, as well as in engineering, centered chiefly around universities; etc.

India : In India, the government has a liberal approach to the promotion and support of indigenous research. This includes several schemes and mechanisms. The scheme to encourage the creation of in-house R&D units in industry enables the industry to establish a good interface with the academic and research institutions, on the one hand, and production units, on the other. Another measure provides support for the establishment of scientific research institutions, and contributions made to such institutions are exempt from taxes. Incentives are also provided in the form of an investment-allowance on the cost of plant and machinery installed in an enterprise using indigenously generated technology. There are provisions by which public-sector entities can provide equity in establishing new units using indigenous technology. Another provision relates to development-projects, in which an invention made at laboratory-level can be tested on a full scale with the participation of the government. Price-control mechanisms give due recognition to indigenous research efforts. Indigenously developed technology is also free from normal problems relating to licensing. There are varieties of other facilities to encourage innovations, e.g. funding of substantial part of research and development efforts. As a result of the new incentives, industrial units in the country have started R&D activities as a result a significant portion of the national expenditure on R&D is contributed by industry.

Other measures taken to improve research-industry cooperation include setting up of Science and Technology Entrepreneurship Parks (STEPs) established by the National Science and Technology

Entrepreneurship Development Board (NSTEDB), working under Department of Science and Technology (DST). The STEPs have been established mainly in the fields of electronics, computers, mechanical engineering, machine tools, automation and controls, chemicals, material sciences, biotechnology and environment. They have been instrumental in the development and commercialization of many products/processes. Other examples include initiation of Home-Grown Technologies (HGT), under the Technology Information, Forecasting and Assessment Council (TIFAC) working under DST and Program Aimed at Technological Self-Reliance (PATSER) under Department of Scientific and Industrial Research (DSIR). The former programme monitors technologies available with laboratories and matches these with the interests of industries willing to venture into development, design and commercialization efforts and the latter provides partial financial support to research, development, design, engineering (RDDE) projects undertaken jointly by industry and R&D organizations and academic institutions.

China : In China linkages between the R&D community and industry were almost non-existent, as late as the early eighties. There were sporadic examples of technologies generated by research institutions, which were provided to the designated enterprises, free of cost. However, the results were invariably failures, due to the reasons that inefficient technologies were forced on to economic exploitation in this manner, which never passed the market test. A reforms period was initiated in the mid eighties in China in which a number of mechanisms were evolved to effectively link academia with industry, viz. the institution of contract research. Examples are: High/New Technologies Pioneer Services Centers (PSCs) - also known as incubators; High Technology Development Zones (HTDZ) - the Torch Programme - the Programme primarily aimed at establishing entities similar to technology parks (with necessary physical and technological infrastructure, subsidized tax rates, availability of risk capital, etc.); the Spark Program with the objectives of promoting application of appropriate technologies in the Village and Township Enterprises (VTEs), etc.

Pakistan : Pakistan is an agrarian country, with nearly half of the GDP being contributed by agriculture. The Pakistan Agricultural Research Council (PARC) established in the early seventies undertakes, promotes and coordinates research activities in all fields of agriculture. Realizing the importance of strong linkages between agricultural research organization and the farmers, an executive body with the name Agri-Business Relations Committee has been set up in PARC. The objectives of the Committee included encouragement of close linkages among the components of the research system, getting feedback on the problems and issues of agri-business firms and agro-based industries, and coordinating with the research scientists for solution, assisting scientists in registration and patenting of designs, technologies, processes, etc., promotion of commercialization of locally developed technologies, designs, processes, etc. and providing assistance to commercial firms in organizing and implementing their in-house research programmes. The modes of collaboration with the private sector include provision of consultancy services, providing assistance in design, development, testing and evaluation of products, market studies, staff training and undertaking collaborative research projects with the private sector. At grassroots level, extension services are provided in order to field-test improved technologies generated through various projects of PARC, before these are passed on for general dissemination among the end-users.

2.3. Promotional Schemes and Regimes of Incentives

By and large, R&D institutes in most of the developing countries have not been successful in commercializing the developed processes, as these processes did not meet the needs of those they were meant for, mainly the private sector. The research in these institutes had been of the adaptive nature, mostly based on indigenous raw materials. The local technical know-how faces formidable opposition, for various political and commercial reasons. In some countries regulatory measures were introduced for the utilization of the process, based on indigenous technology.

The importance attached to utilization of indigenous technology is highlighted in various promotional schemes and organizations and correlated activities. Governments have sought to promote the development and utilization of technology by providing regimes of incentives and other promotional schemes, with the objectives of encouraging exploitation of results of research and concerned patents. Special regimes of tax incentives are prevalent in almost all developing countries, which provide financially attractive advantages to firms and entrepreneurs undertaking commercialization of technologies. Coupled with tax exemptions, preferential treatment is also given to the indigenous technology user agencies. Besides, there are several development finance and banking agencies, which, too, play a role in the commercialization of technologies. They provide project-syndication loans and, in some countries, even venture-capital and risk-financing. Promotional schemes and regimes of incentives constitute a key element in development of technology. In providing these, different countries have focussed on country-specific technology-development strategies.

In Japan, the scheme of incentives has concentrated on R&D and has covered specific sectors such as mining and industries. In the Republic of Korea, regime of incentives integrally covers technologies acquired from abroad and those developed indigenously. Both in Japan and the Republic of Korea, the promotional schemes aim at accelerating the development of small and medium enterprises. In India, the incentives are given to industry not only in terms of tax exemptions and reductions, but they are also compelled to venture on and utilize indigenously generated technologies.

The Republic of Korea has relatively large paraphernalia of institutions and mechanisms for promotion of indigenous research. The Government established Korea-Technology Advancement Corporation (K-TAC) as a public corporation in order to promote the dissemination of indigenous R&D results and foreign technologies to local entrepreneurs, through R&D project-sponsorship, management-consulting, sales of know-how, sales of prototype equipment, etc. The incentives offered under the umbrella of Technology Development Promotion Law (1967) were aimed at reducing the cost of foreign-technology imports and of industry's in-house R&D work by allowing reduced tariff on the import of R&D equipment, deduction of annual non-capital R&D and engineering expenditures from taxable income, accelerated depreciation on industrial R&D facilities and a tax credit for investment in facilities for R&D and engineering-work on commercialization of local R&D results. The Korea Scientific and Engineering Foundation, provides funds for strengthening basic and applied research. Besides K-TAC. Korea Technology Development Corporation – KTDC, Korea Development Investment Corporation - KDIC and

Korea Technology Finance Corporation – KTFC, provide venture-capital (in addition to the commercial banks) to support the commercialization of technology.

2.4. Protection and Promotion of Industrial Property Rights

Lincoln has very aptly said: the patent system adds “the fuel of interest” to “the fire of genius". Inventions and innovations are the bedrock of technology generation, and industrial and technological progress. These constitute the driving force of technology, economy and even culture of a society. Reliable guarantees of granting and using industrial-property rights (inventions, industrial designs, trade marks for goods and service, etc.) are important characteristics of a civilized country. A country’s system for the protection of industrial-property rights is an integral part of the overall system for the protection of intellectual property in a country. The latter caters for the development of national economy, protection and improvement of the scientific and engineering potential, development of foreign trade, stimulation of innovation activity, as well as protection of economic and social interests of the citizens.

One of the most important measures in respect of a country's efforts for protection of industrial-property/rights is the establishment of a patents office. Patents office usually performs the functions of a central executive body and ensures realization of the policy objectives, through the enforcement of legislative and administrative stipulations. Usually the laws are promulgated in relation to the protection of rights in inventions, utility models, industrial designs, marks for goods, services, development of varieties of plants, etc.

A few specific points can be made about the usefulness and feasibility of a patent system in a developing country. First, a patent system requires a procedure for validating claims by applicants that a new product or process represents "a significant technological advance" with clear industrial applicability. The enforcement of the industrial-property protection laws is a matter falling certainly in the purview of the international treaties. The countries have to adopt such treaties in order to be eligible to export freely. The conditions attached to the membership of General Agreement on Tariffs and Trade (GATT) and the World Trade Organization (WTO) invariably require ratification and enforcement of such laws in the member countries.

However, there are certain impediments and drawbacks associated with the ratification and promulgating of such enactments. First, considerable expertise in a particular area is required to evaluate the significance of a new technology. In many developing countries, such expertise is in short supply and it is legitimate to ask whether the limited supply could be more usefully employed in the productive-sector for generating technologies, rather than in the public-sector, evaluating them. A further concern is that, if a country does not discriminate between nationals and multinationals in awarding patents, a vast majority of patents in many countries would be registered and awarded to the multinationals, which are much more active in innovation. If the profits from the foreign-owned patents are transferred abroad, then the answer to whether the country benefits from patenting depends on: (i) whether the product would have been developed otherwise, and (ii) whether the social benefits to the country, at the expiration of the patent, from having that product available are greater than the social costs of paying higher prices for it during the life of the patent.

Another issue relates to the possibility that much of the innovation that occurs in developing countries is incremental in nature, consists of minor improvements to a production process; firms can only benefit from such innovations by keeping them secret.

If market protectionism on the one hand, inhibits the national innovation-mood, it at the same time becomes necessary and only viable alternative to give incubation to the young, immature start-ups. This is necessary to safeguard the local entrepreneur against the breakneck competition prevalent in the international markets. An example in this regard is the manufacture of the Ammonia Compressor for ice-plants and cold storages: restriction on import of new machinery provided impetus to the development of this industry in the local market. The earlier fears of a tendency to establish a monopoly by some manufacturers to deliver low-quality products have been dissipated with the emergence of a number of local competitors in the market. Through a fair competition, the manufacturers have been able to considerably increase the quality of their products.

3 TECHNOLOGY-GENERATION FACTORS AND ENDOWMENTS

One way to emphasize technologies of relevance is to identify technologies that allow exploitation of national resources (factor endowments) and in which the local or domestic firms are already competing globally. The advantage in adopting this approach is that such firms/industry already have familiarity with changing world-markets and the technical know-how needed to convert developmental ideas into products and services. Notwithstanding with this, the nation should also assign a role to itself, to develop leadership in technologies that create new markets. If the earlier option has the advantage that a nation has a historical base upon which certain advances in research can contribute, while the latter may give an impetus to its economic upsurge in certain new areas of research. Semiconductors, advanced materials, information-technology, which did not exist a couple of decades ago, have now assumed a significant economic importance, and these industries are expanding and already provide a large number of skilled jobs in many countries. The relative importance of these technologies differs among countries, based on their respective resource-endowments.

3.1. Importance of Human Resources

In most developing countries, the immediate bottleneck in using science and technology for development is the shortage of qualified S&T manpower. The basic issue is how to build up indigenous capabilities to manage S&T in the national setting. Implicit in this issue are two related aspects - first, how to reduce the current gap in the level of manpower resources, and second, how to identify future needs corresponding to advancements in technology. Proper planning is necessary for both.

An expansion of science and technology activities requires a large base of highly qualified scientists and engineers. This, in turn, implies major modifications in the educational system. In many developing countries, educational systems continue to emphasize general studies more than technical and vocational education. In the developed countries, some emphasize more science than technology. Each has its effect on the manpower it produces.

In developing countries, a massive expansion of science and technology education is required at all levels of education - primary, secondary and university. As this is not possible overnight, long-range plans with clear directions and priorities must be formulated for gradual change. And in the mean time, advantage can be taken of what is available elsewhere. The experience in external education has not been very fruitful for various reasons, such as (i) "brain-drain"; (ii) "inappropriate specialization"; (iii) "defective selection system"; and (iv) "irrelevant scholarship schemes".

The problem of brain drain is well-known. A very large percentage of scholars from developing countries decided to settle in developed countries, after they completed their higher studies (mostly Ph.D.'s) there. The most common reason for the brain drain is the opportunity for material gains. Those who return to their own country after obtaining their Ph.D.'s in some of the famous universities of the developed world, more often than not find that their area of specialization is inappropriate in the situation prevailing in their countries. However, because of their higher degrees from renowned universities, they get key positions in the governmental S&T organizations. And when these people get an opportunity to set up a research laboratory, it is quite natural that they do what they know best (even though it may be completely inappropriate for the country!).

The problem of defective selection and irrelevant scholarship arise due to vested interest. In a developing country, an overseas study grant has many more attractions than the simple opportunity for higher studies. Moreover, in many cases, the other attractions far outweigh the knowledge aspect. On the other hand, the scholarships offered by various universities of the developed countries are not necessarily for studies that are essential and urgent for developing countries. This is understandable because the universities can only offer what their faculty and funding agencies are interested in.

The adverse effects of the foreign education problem can be minimized by (i) proper science and technology policy; (ii) long-term manpower development plan corresponding to the long-term S&T policies; (iii) devising a selection procedure to identify "high potential and (iv) establishing a reward system for achievements. One additional and very important point to be noted is that the problem of anticipating the future has to be dealt with properly. Tools and techniques of technological forecasting can be used for this purpose.

3.2. R&D System

All R&D efforts related to the assimilation of imported technology and the development of indigenous ones, need a technological infrastructure, which comprises educational institutions, R&D laboratories, industry, quality-control and standardization institutions, financial institutions, institutions ensuring protection of intellectual-property rights, such as patents office, and skill-imparting institutions, etc. Each of these institutions supports one or more activities in the chain of innovation. The role of the government in providing infrastructure is of critical importance. The weak technological infrastructure in most of the developing countries has been a matter of concern. The non-existence and/or weak linkages manifest among various institutions mars the isolated achievements of various discrete links in the national S&T and R&D set-up. Most of the institutions working in the developing countries across various sectors of economy have generally not successfully played their intended role in the technology-transfer and development process.

Most developing countries establish R&D Institutes (RDI) with the declared intention of promoting S&T activities. The common problems of these institutions have been discussed internationally and are well documented in recent years. Some of these issues are summarized below.

General inadequacies : Inadequate funds, facilities and manpower are recognized as universal problems faced by the RDIs. The problem of inadequate funding and facilities is aggravated by spreading them thinly over too many research projects. Most projects are at subcritical levels of funding. This is true for manpower as well. Since science-related activities far outnumber development and engineering activities in these RDIs, the distribution of scientists and engineers is heavily skewed towards the former. Therefore, the problem of subcriticality of manpower is aggravated by the absence of significant engineering inputs into the R&D activities.

Most of the RDIs are in the public sector and usually their compensation system is not tied to performance. Consequently, the activities undertaken often do not get the expected intensive application of mind necessary for viable outputs from research efforts.

Lack of gatekeepers : In today's fast-moving technological world, monitoring the evolutionary process and locating the point of departure from which the exploitation of a newly available technology may be worthwhile are deemed critical. High technology centres of excellence usually perform the task of such gatekeepers. The lack of technological gatekeepers in developing countries prevents such a critical activity. Their absence in the S&T infrastructure may result in the loss of many an opportunity for spearheading technology transfer and development.

Planning and review mechanisms : Weak or non-existent programme planning and mechanism precludes effective pre-appraisal and post-evaluation of research projects. No rigorous selection procedure is followed to determine the fields of research in which a developing country can afford to specialize and make a significant contribution, both to improve imported technologies and to produce new technologies. Peer review, including evaluation by expert from outside the organization, is seldom carried out. External review is done only in case of externally funded research programmes.

Emphasis has been placed on the research component, while more emphasis should have been placed on the development aspect. Most basic scientists are engaged in pursuing research per se, with little effort toward commercialization. There are very few engineers employed in RDIs to carry on development activities like pilot plantwork. Engineers are not attracted to do R&D work, and the existing career system often does not encourage them to join RDIs.

Subcriticality of manpower is also caused by too many projects undertaken. No attempt is made to weed out duplicating subcritical efforts, particularly project with low potential for productive use.

Linkages between R&D and Production System : Very weak linkage exists between the RDIs and the production sectors (down stream) or human resources development programmes (upstream). Consequently, R&D efforts are unproductive and often inappropriate. RDIs are run more as academic institutions rather than as industrial enterprises. Support to industry is weak and as the source of knowledge for new industry, RDIs are inadequate.

Bureaucratic overtones : The organization and management of RDIs are frequently modelled on those of government departments. Thus, bureaucratic relationship rather than a collegial atmosphere dominates the R&D scene. Multi-disciplinary task force approach for the solution of a problem is not followed. As a result, the team spirit and the ability to view a problem from all possible angles are absent. Creativity is not encouraged and standard procedures for generating creative ideas are not adopted. Research budget is often not separated from the overhead and salaries budget. As a result, the real input to research cannot be measured.

Examples of R&D institutes in Malaysia and Bangladesh are given below:

Malaysia : In Malaysia, incentives for R&D are being provided in the form of 200% tax exemption for approved research projects. Priority is given to the establishment of an efficient research-management system and the development of research infrastructures, such as scientific-information centres, technology parks, incubation centres, patent offices, and other institutions involved in research, design, consultancy, to facilitate the smooth transfer of technology and the development of new products. Some of the prominent R&D institutions in Malaysia include the Institute for Medical Research (IMR), Rubber Research Institute of Malaysia (RRIM), the Forest Research Institute of Malaysia (FRIM), Malaysian Agricultural Research and Development Institute (MARDI), the Palm Oil Research Institute (PORIM) and the Standards and Industrial Research Institute of Malaysia (SIRIM).

Bangladesh : The more prominent research institutions performing R&D and dissemination of indigenous results of research in Bangladesh include:

- Bangladesh Atomic Energy Commission (BAEC) - its areas of involvement include agriculture, physical sciences, bio-sciences, etc.
- The Bangladesh Council of Scientific and Industrial Research (BCSIR) - it focuses on research and experimental development, with a view to developing appropriate technology for the economic exploitation of national resources in the industrial sector as well as the adaptation and indigenization of technologies.
- The Bangladesh Agricultural Research Council (BARC) is the central organization for coordinating R&D in the field of agriculture in the country. However, BARC does not have laboratories of its own.
- Other R&D institutes in the country include, Bangladesh Rice Research Institute, Bangladesh Jute Research Institute, Sugar Research Institute, Tea Research Institute, Bangladesh Space Research and Remote Sensing organization (SPARRSO). Applied research with market applications is also done in the universities and other related organizations.

3.3. Linkage between R&D and Industry

In a traditional market-based system, the market forces normally determine which ideas are to be supported. In particular, support for R&D projects should derive from competition among industry-generated proposals and should require cost-sharing from industry as a test of market-value. However, given the imbalances in the developing-country market, the government has to make use of certain economic policy-levers to trigger activity in certain areas and to discourage activity in certain other areas. The fiscal and monetary incentives to invest in plant, equipment, human resources and intellectual resources will keep the industry alert in regard to technological developments that can contribute to the continuous success, wherever they take place.

The technology capability gap is somehow a function of scientific education in a country and it takes its roots from the poor contact between the research institute and industry. The reasons, underlying the weak linkage between the industry and the government laboratory is the premise that the research carried out in these laboratories is not relevant to the local needs. The government laboratories, until recently, were themselves not willing to let individuals exploit the commercial potential of their research. The result was an ever widening gulf between the government laboratories and the industry. The communications between the two grew weaker over the years and the industry started to look for the packaged technology from the developed West. No effort was extended to adapt or disassemble the imported technology. The result is a low level of technology-capability to absorb, assimilate or improve upon it.

One major reason for the weak links is the insufficient demand-orientation of the research institutes. Generally, the R&D projects are conceived in-house, so that potential users have little impact on the design. The financial viability is not adequately examined during the phase of output-generation and there is little interaction with potential clients. Consequently, R&D outputs are often viewed by the industries as not being relevant - a fact which, reinforced by the research institutes' weak marketing capabilities, leads to non-utilization of R&D outputs. The suspicious nature of industry towards the R&D outputs of the government laboratories puts some additional barriers in the process of transfer.

It has been experienced in many developing countries that proposals and even projects for product-oriented and customer-oriented research often originate outside the research organization. A salesman or a customer usually points out weaknesses in existing products and explains what kind of improvements would be desirable. Many proposals of the sort, " it would be wonderful if" initially originated from sources other than the research personnel may not be viable technically or feasible economically, to justify investments on research in a resource-constrained research institute of a developing country. However, care must be exercised, since, often inflated cost-benefit analyses by the research personnel, in favour of their proposal, sometimes prove a virtual disaster in the end. Thus, for customer-oriented and product-oriented research, the critical judgement of the R&D manager is very important.

In short, the weak and unsatisfactory linkage, between R&D institutes and the industry, is primarily because of three main causes, namely :

a) General lack of communication, which nurtures a mistrust between the R&D institutes and the industry;

b) Incompatibility of R&D outputs with the technological requirements of potential users; and

c) Inadequate arrangements for the implementation of research outputs.

Other related problems include: (a) a very large number of relatively small research institutes, with size and resources below the critical mass to yield any fruitful results; (b) inadequate facilities in the R&D institutes; (c) low level of motivation in the staff; (d) negligible budgets for actual R&D purposes; (e) lack of accountability; (f) absence commercialization practices; (g) negligible private-sector interests in R&D; (h) supply-driven public-sector R&D; (i) non-availability of design and engineering centres and pilot plants for technology-evaluation and testing, (j) short-sighted vision to read the future changing trends of market etc.

4 FINANCING OF INDIGENOUS TECHNOLOGY UTILIZATION

The spending on the utilization of R&D results has traditionally been a function of the country's spending on S&T. A system for the financing and promotion of national S&T activities is generally made up of a number of elements, each designed to :

- Either enable a particular body to draw funds from various sources of finance and allocate them to certain institutions, for the carrying out of specific S&T activities, and/or
- Encourage certain institutions to carry out specific S&T activities and/or to support them financially.

Financing of new technology is one of the major problems hindering the process of the commercialization. Many commercial and development banks, as well as other financial institutions, loan money for industrial projects, including those which employ indigenous technology. As the practice tells us, project-loan syndication is mostly available for high-technology imported from other countries.

Although, there is no bar on loan-syndication for the development of indigenous technologies, there are hardly any examples of such activity in the developing countries. There are, however, examples where utilization of indigenous technology was delayed substantially, to the eventual demise of its competitiveness and loss of market. The 'manufacture of coal briquettes' (in Pakistan) is one such example where the reluctance of development-finance institution (DFI) to invest caused substantial delay and so the market for cheap fuel was taken over by other substitutes like natural gas. It usually becomes difficult in developing countries to convince the loan giving agencies to invest in such projects that have a local technology content.

4.1. Modalities and Channels of Financing

The main elements involved are briefly described below:

Sources/Modalities include :

- funds from government agencies
- funds from public or private production enterprises and trading firms
- foreign funds
    - foreign governments
    - transnational corporations

  - multilateral agencies
- loans
  - commercial banks
  - venture-capital companies
- private savings, through equity participation
- research grants/research contracts
- royalty payments/profit - risk sharing
- funds of research and higher educational institutions
- subsidies/duty draw backs-premiums/bonuses

Channels include :

- the treasury, which operates by means of the general state budget and other accounts such as appended budgets and extra-budgetary accounts
- promotional and special funds
  - large private foundations
  - national research councils and funds
  - sectoral research councils and funds
  - special funds, either government-controlled or autonomous (generally derived from a turnover tax on industry)
- banks and other national financial institutions
- companies for the investment of venture capital
- organizations and programmes of different institutions

Methods of securing financial resources

Economic surpluses are mobilized by the above-mentioned intermediary bodies, using the following different means :

- tax and duties for general purposes, paid into the treasury
- taxes and duties for specific purposes, paid into promotional or special funds, which may be levied on

  - the turnover or net profits of the enterprises
  - loans
  - exports of certain products
  - imports of certain products
  - royalties
  - charges on public services
- bank deposits
- donations

Methods of allocating financial resources

The financial resources drawn by the intermediate bodies are allocated to users through different methods of financing, such as:

- budget appropriations
- non-lapsable budgets
- contracts for supply of goods or services
- loans granted by banks/international organizations
  - shared risk loans (venture capital)
  - bonus or promotional loans or soft terms loans
- investment through venture-capital/joint ventures/equity participation
- donations for works of public interest

Incentives

The governments can allow the companies promoting the S&T activities and the utilization/reliance on indigenous research efforts, through:

- tax deductions, granted for instance to an enterprise committing a certain amount on R&D expenditure
- total or partial exemption from customs duty for imported scientific equipment

- joint public/private financing, in which the state’s contribution is dependent on a corresponding contribution from the private sector, for example 50% of the cost of the R&D project
- the underwriting by the state-financed institutions of bank loans in cases in which the borrower can offer no real guarantee.

4.2. Financing and promoting use of indigenous research results

Before a decision is made to make use of any of the forms or channels of financing described above, the following factors need to be taken into account:

- the economic situation of the country (including not only the economic situation, but also the respective involvement of the public and private sector, determination of factor-endowments, areas of strategic importance to the country and its preferred objectives of national socio-economic and technological development)
- the type of S&T activities being currently undertaken and the modes of their financing; the different S&T projects are also to be differentiated on the basis of their life-cycle phases, - whether the R&D can be characterized as basic research, applied research, prototype development, upscaling, or pilot-plant production, etc.)
- the probable clientele of the work of such institutions within the country, in the region and in international markets together with the constraints to market their product, if any

Private R&D Spending : Besides the different mechanisms already identified, the interest of the private sector can be appreciably increased by carefully designing the :

- project planning documents (be it in the public sector or in the private sector) to emphasize the reliance on indigenous efforts and capacity building,
- public procurement policies - increased marks in pre-qualification and bidding process be awarded to companies relying on indigenously developed products/ processes, or the ones that disassemble the imported product/process and replace the locally available component through indigenously available products.
- the provision of physical and institutional infrastructure wherein emphasis should be on the consistency of policy formulation and transparency in its implementation.

Non-Availability of Committed Funds : While the difficulties of provision of adequate funding mars the indigenous research efforts, the availability of even the committed resources is not always possible. It is seen, for example, in the case of Pakistan that the S&T allocations have not been used exhaustively. In fact, the total utilization of funds allocated has never gone above the 60% mark in all the eight five-year plans that have been implemented in the country. The main reasons for the non-utilization of the allocations are non-availability of funds at time and considerable delay in processing of development schemes.

The need for actually getting the committed resources can be understood in the backdrop that, while one major constraint in the commercialization of research is linked with the limited budget, the other significant point is the lack of R&D work on major problems of national significance. For this, the requirement entails the preparation and implementation of an adequate long-range research and development plan, geared to face the future needs and this is only possible through a realistic stream of committed resources. The irony is actually not so much in the fact that the Research Institution does not get enough financial returns for its creative effort, but that the industry does not value much the commodity it gets free. The other reason impeding the transfer-process is that, in case of relatively complex processes, the user usually does not get the sole proprietorship even if he is willing to pay for it; hence, the user is not interested to invest in its development and subsequent commercialization.

Leasing of equipment is another way of financing the new technology. The best known example comes from Japan. There, in the early days of development of the computer industry, the government helped establish a computer-leasing company, which purchased large and medium-sized computers in bulk from the "infant" local computer industry, then leased them on favourable terms to local users, mostly corporations. This provided a sizeable domestic market, in which the local industry was able to realize valuable learning- economies before venturing in a major way into the export markets. Such government-supported leasing operations could facilitate the utilization of a range of capital equipment by small and medium-sized enterprises while, at the same time, serving to promote the emergence of a local capital goods sector.

4.3. Equity Participation, including Joint Ventures

In fact, the development of conventional channels of investment financing, e.g. the growth of equity markets, investment banks, etc. remains the highest priority for developing countries. While these do not specifically favour investments in technology acquisition or innovation, they do make it possible for local firms to "learn by growing". The enormous influx of capital into several securities markets in the developing region, in recent years, tremendously enhances the capacity of firms in those countries to undertake new investments and thereby to acquire new investment capabilities. While the investment boom has also fueled a boom in capital-goods imports, the introduction of a range of new production-processes into their industries and of whole new industries into their economies has certainly given rise to important local learning-effects and generation of newer skills. Of course, the mere availability of investment-financing does not ensure its efficient utilization, but presumably, efficient equity-markets and diligent bankers exercise some degree of discipline over those firms that they finance. Reliance on indigenous research efforts offers a cost competitive advantage to new start-ups in the developing countries and it is relatively easier for the capital markets to raise financing, because of the higher risk appetite of equity funds, which are in pursuit of higher returns.

Government can play a valuable function in ensuring the availability of adequate funds for financing of technology. At the macroeconomic level, financial and fiscal policies can significantly affect incentives for domestic savings, hence the mobilization of domestic resources for investment. Price stability tends to favour savings over consumption; decontrol of interest-rates can also provide strong incentives to raise marginal savings-rates. To encourage the allocation of additional resources to technology-enhancing activities, governments can tailor-tax policies to provide fiscal incentives to investments in research and development or technology-acquisition and the training of personnel. In some countries, the government has played an even more active role in financing skill-formation. For example, the Singapore Government assesses a payroll tax on all employers, investing the revenues in a Skills Development Fund (SDF). Firms can then apply for grants from the SDF to finance the costs of training. Since the relevant governmental reviewing-body reserves the right to reject applications, it can effectively steer investments in skill formation in the direction of favoured occupations. Government research-institutes may also have venture capital arms (e.g. the Korean Advanced Technology Corporation, or K-TAC), which provide venture-capital financing for the commercialization of innovations developed within their laboratories.

Since managing venture capital funds requires specialized expertise, some countries seeking to develop their own venture capital markets have chosen to invite established foreign venture-capital firms to participate in joint ventures. Not all countries are at a level of technological development where a venture capital market would be warranted, given the financing needs of local firms. For firms using standard process-technologies in more traditional industrial sectors and still following an imitative product strategy, more conventional industrial financing channels may prove adequate. In such countries, firms are likely to benefit more from assistance in financing the hiring of engineering or management consultants to help them improve the efficiency of production and the product quality. In addition, financing of human resource development - especially technical education and training is among the high-priority areas for countries, which are still seeking to upgrade their technological capabilities.

In most of the developing countries, necessary organizational mechanisms for the purpose of covering the risk involved in the development and commercialization of indigenous technologies, of the state-owned patents and of R&D results are required. But the risk-capital for developing and commercializing indigenous technology is either scarce (India, Philippines) or non-existent (Pakistan).

4.4. Technology Development Banks

It has been suggested that instead of creating a new institution, the developing countries may change some of their existing development financial institutions into a venture-capital company, or may require them to carry out venture capital business as well, in addition to their conventional business. In this respect, the concept of a Technology Development Bank may also be introduced. The major role of this bank would be to provide financial support for:

- all aspects of the introduction, improvement and adaptation of advanced technology, particularly semi-developed technology from abroad, or indigenization of such technology to suit local conditions,
- development of new products and processes,
- support of plant engineering services,
- increasing the availability of risk and venture-capital for development of indigenous technology and upgrading traditional technology,
- financing R&D laboratories and technological institutions, and
- providing subsidies for the commercialization of R&D.

As considerable development financing is indispensable for commercialization of technologies, there is vital need to increase its magnitude and to ensure that it is greater than that set aside for technology generation.

4.5. Risk and Venture Capital, Some Experiences

There is a vast literature on capital-market imperfections in developing countries. Even in developed countries, capital-markets for financing of technology are characterized by special problems. First, and most obviously, investment in new technologies is especially risky. Buying and installing a standard piece of capital equipment poses few risks beyond the normal commercial risk that relative prices will shift against the product to be produced, before the equipment costs have been amortized. When the technology in which the firm is investing has not been utilized extensively or it is a technology whose ultimate shape is not even known at the outset, additional elements of risk and uncertainty will arise. While efficient capital-markets may be able to discount simply on added risk, they do less well in accommodating inherent **uncertainty**. In order to compensate for these deficiencies, specialized venture-capital markets have emerged in a number of countries, probably the most highly developed being in the United States. Venture-capital financing serves to shift some of the risk from the shoulders of the entrepreneur, and somewhat reduces the uncertainty faced by the outside financier, by allowing the latter a share in management proportional to its share of the equity invested in the venture. The incentive to invest in this case is the prospect of very high returns, coupled, of course, with very high risk.

Besides spreading the total risk, venture-capital financing can fill two other urgent needs of an innovative start-up firm. First, it can enable that firm to bring its new product to the market more quickly and, thereby, enhance the prospects of reaping "first-mover" advantages. Second, it can enable the firm to build up its technical and other resources so as to achieve a critical mass, which would permit sustained innovation and create an ongoing concern capable of sustained commercial exploitation of the innovation.

The requirement for risk-capital becomes necessary, as the governments in developing countries are not always in a position to subsidize the risk associated with the utilization of research-results, and the weak resource base of the local entrepreneurs and their limited planning-horizon restricts them in their venture on the new, unproven technology. The local entrepreneurs are naturally more inclined towards quick and guaranteed returns from the imported technology because the imported technology offers the additional advantage of back-up support, both technically and financially.

However, it is now seen in some of the developing countries that fund managers for risk-capital sometimes require sizeable collateral from the new start-ups in the form of tangible assets. Clearly, any such venture-capital market, strongly biased in favour of collateralized lending is not fulfilling its intended function effectively. The assets of these start-ups are frequently intangible, consisting, for example, of the technical and managerial capabilities of its personnel, its proprietary product or process know-how, or, in some cases, sophisticated software. Loan officers trained in conventional investment-financing institutions, in developing countries frequently lack the expertise to evaluate such assets accurately. This further exacerbates the uncertainty of lending to such ventures. Venture-capital firms require technical competence to evaluate projects involving investment again specialized, often intangible assets. Sometimes, they may have to rely on outside consultants, sufficiently qualified for evaluation of specific projects involving technologies in which internal staff lacks expertise.

A number of countries in the Asian region have begun to build up their venture capital markets during the last decade. Korea was one of the first, with several public and private institutions active in the business. The Korean experience illustrates that such institutions can prove viable even in a country that is not on the leading edge of most technologies. Many of the projects financed have involved the introduction of products, which, while not the first of their kind in the world, were nonetheless the first of their kind to be made in Korea. A substantial part of the financing thus went to foreign technology-purchases needed to localize production. The range of products financed in this way is quite broad, including computer-peripherals, industrial controls, medical electronic equipment, electronic scales and automotive components.

The Republic of Korea, as a matter of policy, puts premium on providing risk-capital. The agencies, such as K-TAC (1976) and KTDC (1981), have registered a quantum jump in the availability and use of risk-capital and financial support by way of soft loans and credit for technology-development. Besides K-TAC and KTDC, some other organizations established for venture business in Korea include:

- Korean Development Investment Corporation (KDIC) 1982
- Korea Technology Financing Corporation (KFTC) 1984
- Korea Technology Banking Corporation (KTB) 1992

5 TECHNOLOGY SUPPORT SERVICES

Perhaps, the most essential part of the knowledge of R&D personnel for our purpose is the knowledge of industrial problems and social demands. It is in this respect that R&D institutions in the developing countries are not very strong. While undertaking technology-development projects, there is great need for being fully abreast of the felt needs and technological requirements of industry. No effort can bear fruit unless fairly realistic statistics are available on the national resources, be they raw materials, human skills, financial resources, etc. The indigenous technology-generation efforts start in the developing countries usually on the basis of an import-substitution model. Any effort to select, redesign and improve upon a process cannot bear any fruit if it is not feasible economically. It is clear that this feasibility assessment can be achieved only if the reliance is made on the national resources.

5.1. Technology Information System

Information plays a vital role in technology transfer and development. Developing countries, however, have not yet been able to establish adequate infrastructure for the collection, processing, storage and dissemination of information that is useful for productive purposes. There is a tendency to depend on the public mechanism rather on the market mechanism. In fact, in some countries, sufficient concern does not yet exist for the development of proper technology information system.

A developing country embarking on a program for technology transfer and development needs information regarding alternate technologies, their sources and prices. In today's international scene of trading and of Internet, looking for a competitive edge in the market essentially amounts to looking through the technology itself. Knowledge about the shelf can be gained through an effective information system. However, given the dynamic nature of the technological world, more knowledge about the technology per se is not enough. There is also the need to assess the trends of its change and experience of other countries.

It must be stressed that detailed technology information, which provides a competitive edge, is unlikely to be available through the public domain information systems. It would be naïve to expect that the organizations, which have invested vast amount of money in developing a technology, would make it available to others free of cost. However, information systems especially in present day Internet world can help a great deal in locating sources of such technology.

The usual arrangements needed for information collection and dissemination include institutions for collecting catalogues of books and journals. There are national documentation centers, which can help the research worker in preparing bibliographies and obtaining copies of the relevant scientific publications. With few exceptions, developing countries do not exchange information, except through the services of the developed countries. One of the main reasons for this is that whatever rudimentary S&T information network that exists in some of the developing countries, this is still firmly oriented by structure and training to receive input from the developed world.

Korean Experiences : In order to facilitate the exchange of technological information and expertise and to seize the needs of industry, the Industry-Academy-Research Institute Cooperation Research Centre (IARCRC) was established under the organization of the Science and Technology Policy Institute (STEPI) of the Korean Institute for Science and Technology (KIST). The main functions of the Centre include (i) transfer of intellectual properties from Government-sponsored Research Institutions (GRIs) to industries, (ii) free technological consultation (compensation given by the Government) and (iii) provision of specialized information in various technological fields. In 1994, the Technology Development Consulting Centre (TDCC) was established under the IARCRC, to meet industrial needs in various technological areas like assessing results of research available with GRIs for upgrading or scaling to a desirable economic size.

The free flow of S&T information is a necessary condition for building indigenous technological capability. Periodic fairs and exhibitions contribute one forum commonly used for demonstration and dissemination of technological information. A novel approach in this respect consists in the Research, Development and Display (R D & D), which is the slogan of technology-dissemination. Technology is displayed through several channels, such as festivals and exhibitions. Various products and technologies are also disseminated through exhibitions organized by the Chambers of Commerce and Industry.

5.2. Standardization and quality control

It is not enough just to produce: one must also sell one's products, and successful marketing today is much dependent upon the control of quality. Standardization performs a number of valuable economic purposes. In the present-day competitive industrial society, quality-assurance and certified standards are of crucial significance for successfully commercializing various technologies. The technologies have not only to be proven for utilization, but the products must also be proved adequately reliable in terms of quality. Otherwise, they may not be able to stand the market forces for long.

The main objectives of standardization are: (a) to provide a means for communication between the manufacturer and consumer; (b) to ensure interchangeability; (c) simplification (or reduction of variety); (d) to ensure safety, health and protection of life; (e) promotion of overall economy; and (f) elimination of technical barriers to trade.

The detailed relationship of standardization with technology development has sometimes been questioned. Researchers have argued that standardization may discourage exploration of potentially fruitful avenues of research. Fortunately, as the technologies move through frequent changes, standards also evolve in the process, are challenged and so a substantial amount of innovative activity revolves around the struggle between competing standards.

Standardization allows various equipment manufacturers to utilize the same supplier of a particular component, thus allowing for achieving economies of scale and so a reduction in the cost of inventories is possible for the users. Design-costs are reduced, as are the tooling-costs and set-up time for equipment. It may also allow for greater interchangeability of parts, which should stimulate greater competition among suppliers of parts. Furthermore, there may be economics of scale in the supply of complementary products, as well as in the provision of repair services. For example, standardization of microcomputer operating systems (e.g. Windows) makes possible the large-scale production of standard applications software.

Another advantage of standardization is the reduction in costs of learning: a person trained to use a particular PC would be able to utilize any other compatible PC-machine, with little or no additional training. Furthermore, standards reduce the costs of transaction by diminishing uncertainty regarding the quality and performance features of products. If a product is known to meet certain well-defined standards, the buyer can be assured, with a high degree of probability, which it will perform in a certain specified manner.

When a government sets the standards, it normally relies on technical committees, consisting of representatives, from manufacturers, users, government departments and university laboratories, to work out the specifications. To implement standards, an institution is normally required, which can establish sampling and testing procedures, institute a certification program, and provide technical advice to manufacturers to bring their products up to the standards. A certification program, wherein qualified manufacturers are issued licenses attesting to their conformance with standards, is equivalent to a national quality-assurance program. Since a standards body cannot monitor continuously the quality-performance of every certified manufacturer, the program then requires to be complemented by quality-assurance programs within the productive enterprises themselves or, where the industry consists of many small-scale producers, in specialized research institutes or testing laboratories serving that particular industry. The national standards body would need to endorse the sampling and testing programs of such institutes and laboratories. Independent testing laboratories are, in fact, an integral part of standards implementation.

To ensure the reliability of the equipment used in testing and measurement, whether in the firms' own laboratories, in the independent testing laboratories, or in a central research laboratory, a regular system of calibration needs to be instituted. Normally, by the common hierarchical "calibration chains" approach, the closer one approaches the central national laboratory, the stricter are the conditions under which instruments are calibrated. In practical terms, what matters is how well the instrument performs measurements under a range of actual operating conditions, it may be useful for the laboratory that calibrates the instruments to do so under a wide spectrum of conditions than are likely expected to be encountered in actual use. This approach may be particularly appropriate to developing countries, where the operating environment for the measuring instruments may not be as readily controllable and predictable as in developed countries.

The enunciation of ISO 9000, 14000, etc. series programs have opened a new era, wherein the certification of standard organizational procedures have been advocated as strong proponents of the market competitiveness of firms in the local as well as international markets.

5.3. Organizational Support Services for SQC

Various types of organizational support services are available for standardization and quality control in the developing countries :

Egypt : In Egypt, there are two bodies concerned with standards and standardization: the Standards Institute, which is affiliated to Academy of Scientific Research and Technology (ASRT), and the Egyptian Organization for Standardization, which is an agency for the Ministry of Industry. They are responsible, respectively, for primary and secondary standardization. The former is a scientific body concerned with industrial, scientific and legal metrology. The latter carries out all the normal functions of a standardization organization, promulgating norms with the assistance of the normal producer/consumer specialized committees, in which the Standards Institute participates, as well as research and technological specialists in the relevant disciplines, and awards quality marks.

Japan : Examples from Japan include the Japanese Industrial Standards (JIS). Currently, pre-standardization research is being promoted in the country in a number of fields, so as to improve prevailing standards or to introduce new standards. The functions of JIS are to promote :

a) improvement of quality and rationalization of production;

b) simplification and fairness of trade; and

c) rationalization of use (or consumption) through appropriate and rational standards.

Korea : In the Republic of Korea, the various functions of standards and standardization were scattered over several organizations prior to 1970s. In the middle 70s, the Korea Standards Research Institute (KSRI) was established, for the purpose of modernizing standards systems in the Republic of Korea. KSRI is presently the central authority of the national standards system, which provides calibration services and performs research on precision measurement and development of precision instruments.

Philippines : In the Philippines, the Philippines Bureau of Standards (PS) prepares standards and arranges for certification of goods. The National Institute of Science & Technology (NIST) of the Philippines operates and maintains national standards of measurement for the country and renders technical services, such as repairs of scientific instruments and testing/analysis of materials, products, and commodities. It acts as the arbiter in cases of conflict on scientific and technical tests and analysis. There are a number of other standards certification organizations in the Philippines, such as: National Standards and Testing Laboratory (NSTL), Food and Drug Administration (FDA), Products Standards Agency (PSA), the Philippines Standards Association (PSA). The later is a private body providing assistance to the Product Standards Agency and other organizations and private enterprises.

Pakistan : The counterpart organizations in Pakistan include Pakistan Standards Institution (PSI), Pakistan Quality Standards Research Institute (PQSRI), Pak Swiss Training Centre, Central Testing Laboratories, and Metal Industry Research Development Centre (MIRDC).

6 COMMERCIALIZATION OF TECHNOLOGY

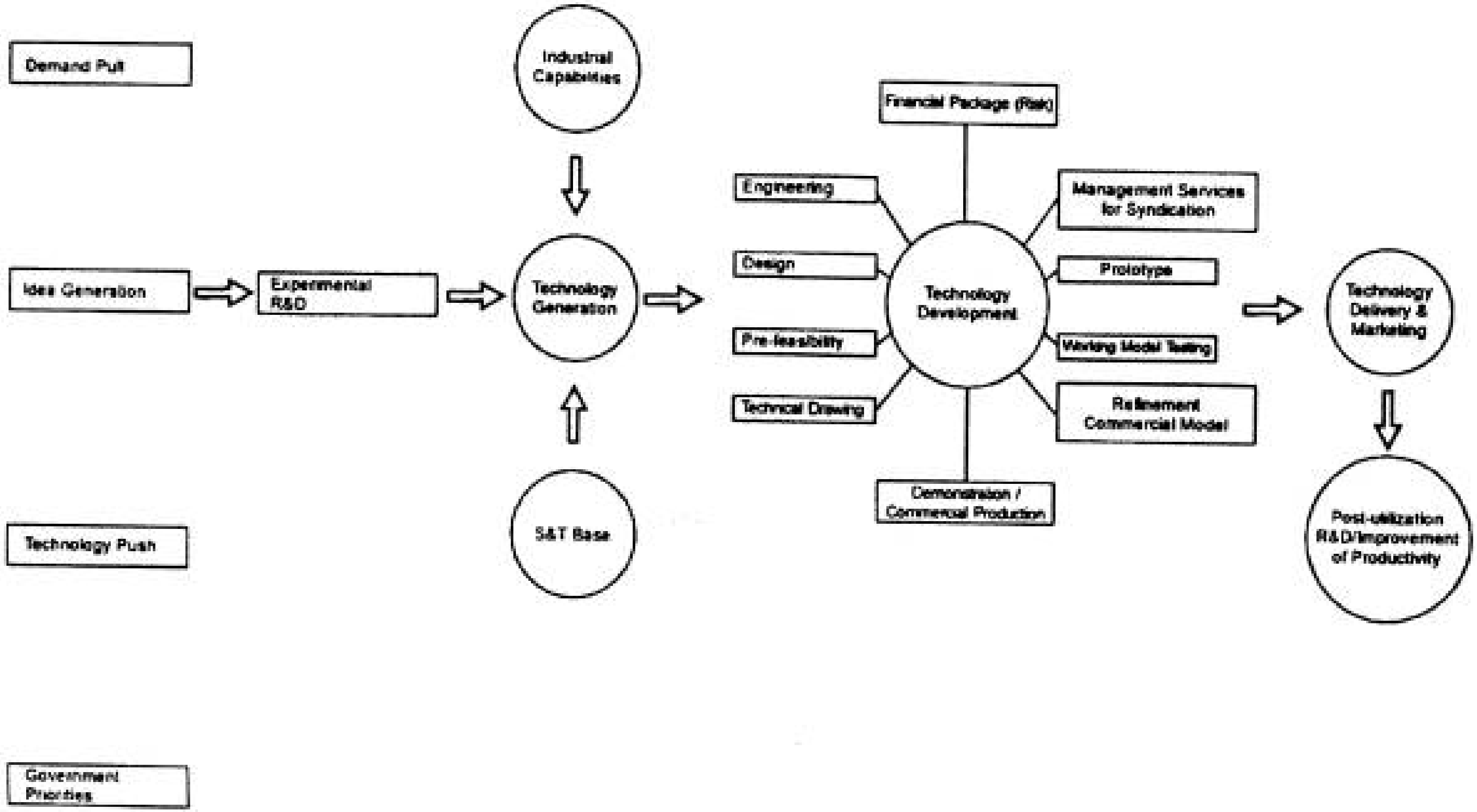
Commercialization of Technology is essentially a process of moving research results from a research environment onto a successfully marketable product. Commercialization is often thought of as an orderly series of steps i.e. defining a product (or process), building a prototype and testing its feasibility, completing product development and design, starting a production-phase and finally passing the manufactured product to the marketing and sales department. But perhaps this sequential and orderly path is too simple an appreciation of what it actually is.

The development of technology and its subsequent commercialization is a very complicated process. After an idea has been carried through from conception to proof-of-concept, the difficult tasks of identifying and evaluating potential markets, attracting sufficient financial resources, and overcoming scale-up and manufacturing problems must still be undertaken by industry. This process involves high risk, long lead times, and many threats of failure. In moving any technology out of the laboratory, an industrial firm must be convinced that the often-costly development required for a commercial product or process is worth the risk involved.

6.1. Process of Commercialization

For the service and technology to be effectively applied, there is need to complete the total innovation-chain, consisting of basic research, applied research, design and development, prototype fabrication, up-scaling, extension, building of awareness, production engineering, design and consultancy and production of services. A schematic presentation for the commercialization of technology is shown in the Figure. Commercialization begins when a business identifies a way to use scientific or engineering advances to meet a market need. The process continues through design, development, manufacturing ramp-up, marketing, and also includes later efforts to improve the product. While it is often viewed as a linear process - a series of steps performed by people in different functions-many see the process as a series of overlapping phases that involve many functional groups simultaneously.

Commercialization of Technology



The Case of Korea : In the 1980s, the Ministry of Science and Technology in the Republic of Korea launched the Center for Research and Development (CRDC) to promote the transfer and commercialization of new technologies from universities and GRIs into private industry. One critical function of the CRDC was to provide long-term loans to support the process of commercialization in private firms, as well as for the consolidation of marketing activities in the field of technology-based venture business. The Government provided 80-90 percent of the total R&D investment to R&D institutes involved in national R&D projects for core and fundamental technology-development, industrial technology, alternate-energy technology development and other programs formulated by the Government. It also provided financial support of up to 50 percent of the total cost to individuals or small firms for commercializing new technologies. Since the 1970s, the research programs, financed by both Government and industry, have focussed on developing strategic, high-risk, high-cost technologies that could not be developed by industry alone.

6.2. Project Feasibility Study

Feasibility study of a project is necessary in order to obtain loan and equity participation from financial institutions. It should cover various points in the technology-development chain, such as the availability of technology and alternate sources, costs involved in the commercialization of the project, availability of raw materials, and their alternate uses, market conditions and their demand projections, and the various socio-economic and environmental conditions and constraints.

The importance of availability of a financial feasibility-study can be understood in the backdrop that the potential customers. Particularly the small and medium size industrialists, like to obtain not merely the process or the product design, but a total proven package of product/process, plant engineering, backed by professional and financial guarantees. The laboratories which are in position to offer these services, such as market research, product research, consulting engineering services, etc. along with the normal output of technology, have better chances of selling their product i.e. research output. The research efforts are focused on the development of indigenous technologies rather than tracking, undertaking and absorbing international technological trends in those fields most relevant for domestic firms.

Japan : The Japan Small Business Corporation which is entrusted with the responsibility to promote transfer of technology to the small and medium enterprises, conducts developmental activities related to design studies, trial production and operational studies.

Korea : In the Republic of Korea, the Korea Institute for Economics and Technology (KIET) plays a major role in conducting feasibility studies. KIET undertakes both micro and macro-level analyses of the industrial sector, in order to enhance business viability and to assist the Government in the formulation of industrial policy. It analyses industry by sectors and conducts sector-wise and sub-sector level studies, and also conducts feasibility studies when an industry or area of interest or a potential business opportunity is identified. These studies usually include analysis of market potential for success in the industrial environment of the country. Apart from government and industry, regular consultative and extension services are provided to individual entrepreneurs, covering technology, marketing and financing, especially services covering management techniques, quality improvements and cost-reduction, development of new technology and new products.

Philippines : National Science and Technology Authority (NSTA) in the Philippines renders technical assistance, in the form of consultancy and other related services, for consulting clients and helping people utilize S&T and management information. Other agencies providing assistance to the probable entrepreneurs include Philippines Invention Development Institute (PIDI) and the Technology Utilization Support System (TUSS).

India : Feasibility studies in India are done by various organizations. For instance, the Technical Consultancy Organization (TCO) of the Indian Finance Corporation provides a package of consultancy services, from conceptualization to commissioning of projects. The National Research Development Corporation also prepares feasibility study on some selected processes, covering market, technical and financial aspects of the project in question.

6.3. Engineering Consultancy and Design Services

Capabilities in design engineering, pilot plant, quality control and market research are essential for the transformation of R&D results into commercial production. The essential link between the R&D inventions and production and service enterprises is provided by the engineering design and consultancy services. Engineering and design organizations are a very important mechanism for utilizing indigenously developed technologies and can make significant contributions in operationalizing the technology development until the stage of its commercialization, from the feasibility study to the promotion of technology exports. These organizations can undertake the activities related to establishment of industrial units and infrastructure facilities from the planning and designing stage to the erection of plant and maintenance.

Engineering services in Japan can be divided into two types, specialized and comprehensive. Specialized engineering companies perform engineering work in specific fields independently to multi-clients, or they do plant engineering as affiliates to parent companies. Comprehensive engineering companies conduct not only engineering work, but also construction of plants, sometimes even manufacturing and sale of machine and equipment. The study results of the Japan Small Business Corporation are widely disseminated among small and medium enterprises in the form of orientation as well as demonstration for various industry groups. Several other promotional organizations in Japan such as the JRDC, AIST, research institutes and corporations undertake activities pertaining to engineering design, prototype products or pilot-plant / equipment development.

In Korea, engineering firms undertake plant engineering services as also specialized engineering services in different fields of engineering such as design analysis, investigation, purchasing and supply, testing supervision, trial operation, evaluating, consulting, technical feasibility, data processing and analysis, maintenance and operation, application of scientific and technological knowledge of high quality and research and development.

6.4. Marketing Assistance

Motivation of the private sector in generating, developing and utilizing technologies are basically market oriented. In order to boost the efforts of entrepreneurs in utilizing technologies developed indigenously and in order to help them alleviate or tide over the difficulties encountered specially in the initial risky phase in commercializing technologies – post investment assessment is very essential, specially for small scale enterprises. Difficulties faced by the entrepreneurs in the initial phase in commercializing technology are of various types such as operational, marketing and financial, etc. They need logistical support to penetrate the markets.

Post-investment assistance for successful commercialization of technologies includes market development/ preferential purchase, technical and managerial assistance. These are besides services in testing and standardization and technology information. In some countries post investment assistance is offered in the form of price preference on indigenously developed products. Import controls in the form of tariff barriers such as imposition of customs and/or other import duties on selected goods imported in the form of non tariff barriers such as import prohibitions import quotas and import permits, are also used as devices for protecting the market for the indigenously developed products.

6.5. Management Techniques

Management can play an effective role as regards proper selection, completion and commercial application of R&D – management techniques can improve linkage between 'technical innovation' and ' marketing'. In the context of management of S&T system and mechanisms for S&T development, a prominent feature of the Japanese approach to technology development is that the technology transfer includes the management aspect of technology as one of its essential ingredients. This is indeed very broad and comprehensive conception of technology. The five components in the pursuit of technology development have been identified as (i) Material (including energy), (ii) machines (equipment and machinery), (iii) manpower (skilled workers and engineers), (iv) management (technological management and managerial techniques), and (v) markets. In the sphere of engineering, there has been a continual feedback between the laboratory and the job site, as part of Japanese management techniques, without making a distinction between the laboratory and the job site.

Success of a result and industry-oriented project and its commercialization hinges to a considerable extent on its management, both in the research institutes while it is being developed, and during the process of the delivery of indigenous technologies. Management techniques play an important role in providing a link between technological innovation and marketing. Assistance in management techniques is, therefore, an important part of post-investment assistance. This is specially true in case of commercialization of technologies generated by the R&D institutions. This is because the S&T institutions are generally modeled on government/university standards and systems of management and are sometimes insulated from the development need of the country, patterning their research objectives and methods on those of the advanced countries.

Some of the managerial problems in research institutes are:

i) Lack of management capability;

ii) Meagre resources;

iii) Lack of competition and incentives for creativity;

iv) Failure to introduce an interdisciplinary approach;

v) Lack of team spirit in research;

vi) Failure to build credibility.

Managerial and marketing skills are necessary in the commercialization of technologies on several grounds. Entrepreneurs and assistance in conducting market survey, and government measures are required for promoting manufacturing and marketing of products and processes.

Post investment assistance, which is required at different stages in the development and commercialization of indigenous technologies such as for development of prototype, product improvement etc., is specially necessary in marketing a product, and in terms of management techniques, feasibility study etc.

In the countries of the Asian region, there is one or other kind of programmes for providing assistance of entrepreneurial type and/or required in management and marketing techniques, through mechanism and magnitude of such assistance vary from country to country.

The management and marketing assistance in the Republic of Korea is provided by the Korea Technology Advancement Corporation (K-TAC). It is provided in the commercialization of research results using the know-how generated by various institutes, by way of promotional activities such as:

i) Marketing and sales of research results and their related industrial rights.

ii) Sales of prototype equipment and by-products of research development work.

iii) Sponsorship of additional R&D when required.

iv) Management assistance and market research

6.6. Patents Exploitation

Patents are not commercially exploited owing to many reasons: lack of commercial potential or feasibility, inadequacy of risk capital and technology base, lack of entrepreneurship, etc. It has been observed that there is a lack of maintenance of record on the commercialization of technologies. The data and information generally available on the subject of indigenous technology usually cover the aspect of technology generation much more predominantly, whereas the aspects related to utilization of technologies are not covered with matchable concern. Even with respect to technology generation, the emphasis has conventionally been more on input rather than output. Thus data and information available have heavily concentrated on input factors of technology generation such as S&T budget allocation and S&T manpower, S&T and R&D institutions, R&D personnel and R&D outlays, etc. As regards output, the information is generally available on patents. Finer details as to how many patents have been subjected to compulsory licensing, etc are not easily available, possibly for want of such practice in reality. This is indeed a significant matter since indigenous technology base is a determinant factor of such exploitation of patents and industrial property rights.

In this respect, the fact must be underlined that in a very significant way, patents reflect the state-of-the art of the technologies being developed and of the body of available technical knowledge, by way of the technical specifications they contain. However, such visible, public and protected technical knowledge is only one side of the coin. The other side is the know-how, which is invariably an indispensable factor for working patents. Data and information on know-how and its commercialization and utilization is not maintained, since there is yet no legal regime – nationally or internationally, which governs know-how.

However, what is appreciable is that out of the technologies generated and utilized by the developing countries, some have also contributed to the technology development of other countries. This is an area where in their transactions inter se, the developing countries have built-in advantages and which is susceptible of greater cooperation – both regional and international.

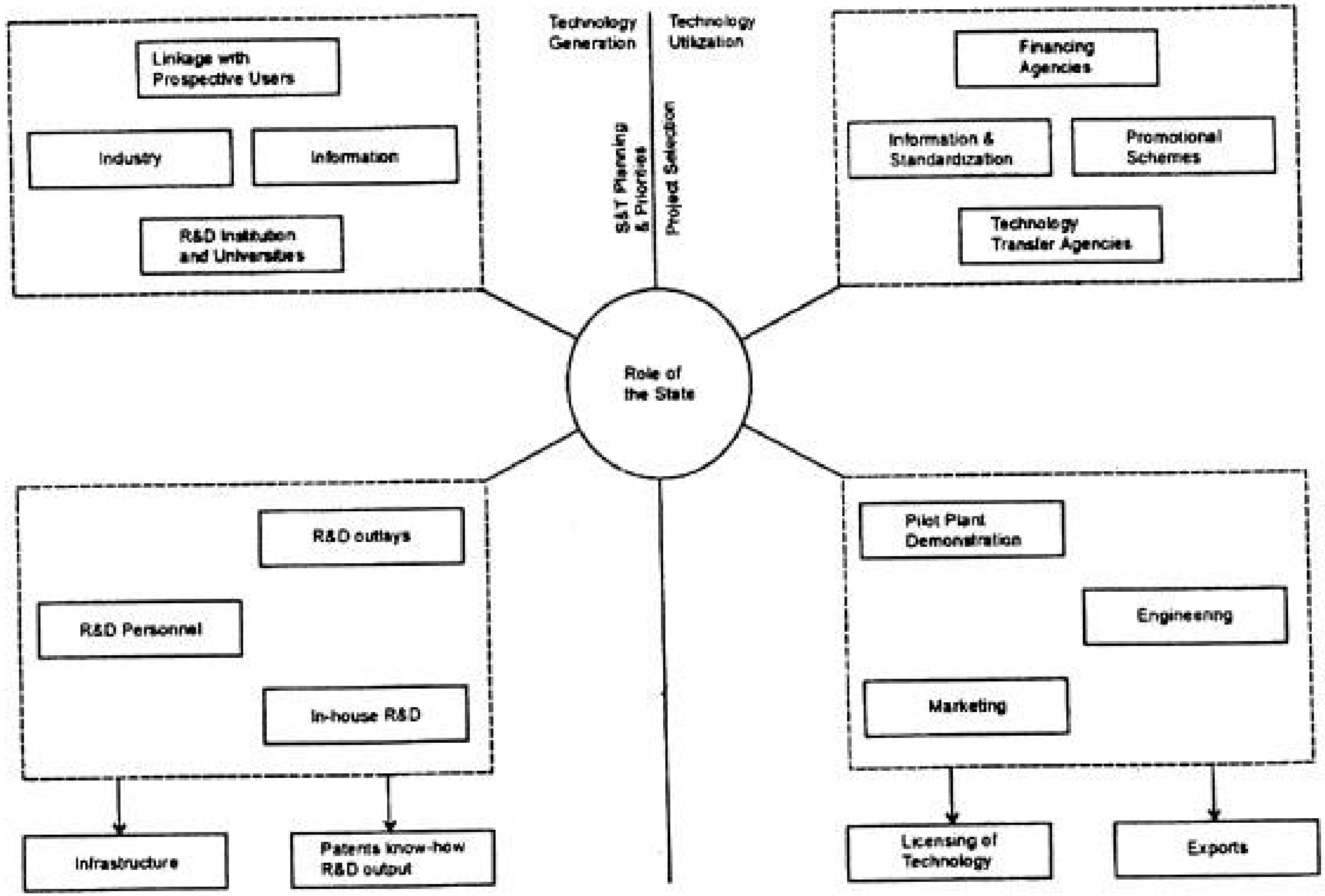
7 ROLE OF THE GOVERNMENT

The importance of the government's role consists in making "the pulse of industry" felt within R&D a routine part of industrial activity". While the governments want to develop technologies with all earnestness, their efforts cannot meet with success unless they were to play an active role in involving industry in the process of technology generation and specially in the process of its commercialization. Indeed, the need for government action in the technology utilization is greater than in the technology generation, which can principally be the vocation of the in-house R&D units.

Utilization of indigenously generated technologies is a long drawn out and cumbersome process, requiring a variety of measures, some of which are dependent on the government directly; others are dependent on the active participation of industry – firms and entrepreneurs – but necessary orientation and direction has to come from the government. With respect to the contribution of the indigenously generated technologies for rural development too, the operational role of the government is essential for carrying the technologies to the grass roots.

A fact which should not be lost sight of is that whereas R&D institutions need monitoring, control and evaluation in the generation of technologies, firms and entrepreneurs need stimulation, encouragement and risk-sharing in technology utilization. Moreover, various support services such as standardization and quality control, technological information, S&T infrastructure etc. are needed for technology utilization. All these have to be provided by the governments, and are dependent on their role – interventionist or catalytic, administrative or executive and direct or indirect. (See figure depicting various facets of the government role). The developing countries have, therefore, to well define the parameters of the role of government, both at the technology generation and technology utilization level.

Facets of the Government Role



7.1. Experiences of Japan and Korea

It has rightly been observed that the success stories of Japan, the Republic of Korea and, to some extent India, have clearly demonstrated the favorable result of direct government intervention. In Japan, multidisciplinary research laboratories with common goal thrived under the directional role of the government. Japan's success in technology development since the early 1950's shows the importance of the governmental promotion for innovation activities. Japan has successfully promoted its technological development by concentrating its efforts on industrial innovation, based on import of basic know-how. The interventionist role of the government in the Republic of Korea for technology development pertains to country's historical tradition and the government plays a vigorous role in encouraging and supporting industry for developing and utilizing technologies.

As far as the guiding role of State in technology transfer and development is concerned, the east Asian experience points to the need to establish a balance between State planning and markets, which accords a substantial role to the state as the executor of a national economic interest. The relationship between state and economy is more organic and multifaceted and the state's impact on economic changes depends heavily on its broader "non-economic, social and political influences".

In Japan and the Republic of Korea, the State has acted to guide markets and modeled the competitive process even by the direct coercion against sections of business class, and the distinction between 'public' and 'private' has been blurred. Intermediate organizations such as industry and farmer's associations, hybrid state/private institutions acting as 'transmission belts' between state and economy, especially the Republic of Korea, have also played an important role. As the experience of these countries shows, the government can identify industries for their up-gradation, and provide stimulation and incentives for industrial growth.

7.2. Technology Generation and Development

Most governments in the developing world today are undertaking major roles in the "formulation, appraisal and implementation of technology-oriented projects". As far as governments themselves undertake industrial R&D, their role is required, in effectively correlating these activities with the industrial milieu. It is essential to take measures for a sound project selection to monitor and control the process of technology generation and to show an incessant concern for the industrial application of the technology being generated. As far as R&D by the industrial sector is concerned, fiscal policies couched in the form of tax credits, grants, risk insurance etc. coupled with other appropriate incentives can motivate the private sector to invest in in-house R&D.

Government initiatives are most needed in the areas which required high-risk and/or long term investment, and which private industry is unable or unwilling to undertake alone. In addition to undertaking joint research with industry, governments are, therefore, sponsoring large R&D projects in Japan and in the Republic of Korea – projects that require long gestation periods. Even where governments do not directly undertake industrial R&D, they have to provide support services such as higher, specialized educational infrastructure for standardization and quality control, technological information services.

Among the several facets of the government role in utilizing indigenous technologies, one can mention the following:

- providing risk and venture capital for promoting technology commercialization process;
- undertaking necessary risk for technology commercialization or sharing such risk with private industry;
- market protection afforded by policies for promotion of indigenous technological capacity by way of a protected market (with a phased reduction of the extension of protection);
- apart from market regulation, the purchasing policies giving preference to indigenously developed technology products through mechanisms of public procurement.

The role of government is also important as regards support for promoting domestic engineering and consultancy services. Most developing countries place great emphasis on protecting and providing domestic market for local engineering firms either by insisting on making them prime consultants, or as a second best, alternative, sub-contractors. Governments play an important role in dissemination of indigenously generated technologies through different modes such as recognition, promotion and appreciation of inventive and innovative activities, exhibition and demonstration of technologies generated indigenously, etc.

It is indeed paradoxical that in countries where the government assumes directly the role of undertaking activities for generating technologies by their R&D institutions, the necessary successive role of the same government in assuming the tasks involved in commercialization of their research results including risk coverage is not undertaken to any appreciable measure. On the other hand, in countries where the government plays by and large only a promotional role for stimulating activities of technology generation rather than themselves undertaking such activities, their role in undertaking necessary tasks including risk-sharing, fully or partially, in commercializing industrial R&D generated technologies is by far more significant.

7.3. Need for Bridging the Gaps in Policy Implementation

The gap between declared policy objectives and aims, and the practical shape the policy take upon being implemented has been found to impair the promotion of indigenous technology utilization. The importance of the government’s role lies not only in lying down policy but also in efficiently following it up for its effective implementation.

The implications of deficiencies and drawbacks in the effectiveness in executing the policies for promoting indigenous technology utilization are indeed a matter of primary concern when viewed in the light of the fact that the governments themselves fund the bulk of R&D for generating technologies in most developing countries.

It is therefore, suggested that the governments must pay special attention to the need for making an assessment of the implementation of policies, and their de facto state of the art with a view to identifying gaps, deficiencies and drawbacks in their follow up and execution. Evidently, factors could affect or impede implementation of policies. Nevertheless, in areas where policies can be strictly enforced by proper monitoring control and checks, such as regards the technology generation process, there should be no slackness.

The “technology push” approach should not be resorted to in order to sanctify shortcomings of the efforts at the technology generation level without being required to demonstrate technological innovative faculty, and without being ab initio tied to utilitarian consideration in terms of project selection, and at large, to accountability for technology performance. The technology extension services, in the agricultural section, provide a good lesson of how technologies can be pushed to the grass roots in the developing countries.

In the final analysis, there does not seems to be a duality in the technology push and the demand pull approach. In effect, both these approaches form a part of a unified strategy for successfully commercializing technologies. They are not conflicting or contradictory but rather complementary. The demand-pull approach yields results only when technologies are ‘pushed’ by the state – what is of utmost importance is to push right type of technologies with the right kind of policies, and with requisite support services, backed by necessary means. Technologies promoted and pushed wrongly or without necessary means could only result in frustration. There does not appear to be any reason as to why normally “pushing” will not be “pulled” by demand since the growth of the firm and the entrepreneurs as also of the nations feeds on technology development and utilization.

8 CONCLUSIONS AND RECOMMENDATIONS

Planning and implementation of technology development policies in the developing countries does not yet find an integral place in socio-economic development, to which it is indeed a core activity. Nor is it governed by a system of proper evaluation of a country's resource endowments, development needs and S&T potential and capabilities. In the process, R&D programmes and projects, as regards the process of technology selection and development are not well conceived or properly developed and evaluated.

Many of the problems and constraints that have been described in the proceeding sections are owing to such a state of affairs. It appears that, on the one hand, the process of technology development, including selection and undertaking of R&D programmes and projects, require a closer look and in-depth examination, and on the other, the modality of intra-country transfer of technology, specially the way a transaction takes place and is given material effect need to be subjected to a detailed investigation and critical examination with the objective of assisting Muslim countries in better transferring and utilizing indigenous technologies. It would be very useful for these countries to hold consultations and to deliberate on these at national and regional levels to increase their activities of development cooperation.

Needless to say, it is the successful utilization of technologies that can make significant contribution to strengthening a country's technological capabilities. One of the essential condition for this is to create and sustain an industrial environment in which there obtains a continual rapport and feedback between R&D personnel and the industrialists/entrepreneurs with a close look at the market demand. Experience relating to effectiveness in indigenous technology utilization, moreover, is demonstrative of the significance of private research supported and encouraged by government.

In view of the above and in keeping with the present study, a set of recommendations are being given below, addressed to government and policy-makers, to R&D institutions and technology generators, and to industry and entrepreneurs with the expectation that they would find them useful and take appropriate measures for giving them necessary follow-up.

8.1. Addressed to the Governments

i) The governments should, as a matter of norm, devote larger financial resources to technology utilization than those devoted for mere R&D so that efforts in technology development can bear fruits.

ii) Aspects related to technology application and utilization of technologies in a country's socio-economic environment should receive greater commitment by the governments for accelerating technology transfer.

iii) The technology users, particularly small entrepreneurs, need indigenous technologies to be transferred as an integrated package so that they are not subjected to multiple transactions in acquiring technologies. This should definitely take care of the areas relating to feasibility studies, know-how, trouble shooting, quality control, raw materials procurement, managerial and marketing assistance and above all, risk capital.

iv) Standardization and quality control measures should be significantly upgraded so as to promote creditworthiness of indigenous technologies. Standardization is to product what patenting is to invention – both must apply a sound criteria and valid test so that inventions, in fact, meet the requirements of patentability – inventive steps, industrial applicability etc.

v) An important consideration regarding the government role is that it should be directional, providing an adequate set of incentives and promotional environment. Experience indicates that governments – as a public entity – can play the role of catalyzer more effectively for assisting industry and business.

vi) There is a need for better organization of patent offices to strengthen mechanisms for technology generation and utilization.

vii) There is a need to adopt integrally with their industrial development programmes suitable policy measures and incentives for promoting in-house R&D in the private and small-scale sector. It must also be ensured that such promotional policies are effectively followed up during implementation.

viii) In order to avoid possibilities of mismatch in S&T manpower and R&D personnel deployment, it is recommended that countries should undertake prospective planning based on technological consideration for development. The governments should also take timely measures for the formation and training of science researchers and engineers.

ix) Industries must be given greater encouragement and necessary financial incentives for sponsoring research programmers in R&D institution.

8.2. Addressed to R&D Institutions and Technology Generators

i) R&D institutes engaged in industrial research should strengthen linkages with industry by setting up industrial consultancy cells to coordinate technology transfer activities.

ii) Stress should be more on contract research with industry than has been the case hitherto with enhanced commercial interest and business-like spirit.

iii) Greater attention should be paid to qualitative aspects of manpower development programmes (including management and marking areas), in addition infrastructural development.

iv) Institutions involved in industrial research should pay greater emphasis on technology utilization and transfer aspects/problems rather than limiting themselves to technology generation.

v) Deliberate and systematic efforts must be made to involve the user agency right from the conceptual stage to avoid pitfalls and ensure effective Feedback.

vi) As far as possible greater efforts should be made to develop technologies appropriate for small-scale enterprise/industry.

vii) Suitable monitoring mechanisms must be devised for ensuring proper return on investment in terms of proven technologies and their contribution to public welfare or commercial utility.

viii) As far as possible, the technologies developed must be scaled up to the level of pilot plants to prove their commercial viability.

ix) The technology transferring agency should explore the scope of joint ventures as a transfer modality so that it is involved in the process of development of technology along with the entrepreneurs and end-users.

x) Perhaps the most essential part of the knowledge of R&D personnel is understanding of industrial problems and social demands. While undertaking technology development projects, there is vital need for ensuring their conformity with the planning priorities, as also for catering to the felt needs and technology requirements of industry.

8.3. Addressed to Industry

i) Industrial sectors must clearly identify areas requiring research backstopping so that theresearch institutions and organizations can better align their operations with the demands of industry. This will result in optimal utilization of R&D resources and avoid duplication of efforts.

ii) Industry must make efforts to increase in-house R&D activities and to be amenable to greater degree to contract research with the R&D institutions it must be more responsive to the drawbacks and constrains in the R&D institutions to suggest the ways and means of remedying them.

iii) Industry should seek to participate in R&D research planning in the areas of its concern, so that social demand is embedded into research projects.

iv) Entrepreneurs as the licensee should constantly apprise the technology transferring agency and the government about the problems and constrains encountered in commercializing technologies. In this respect, the small entrepreneurs could act as a group of consortium. Industry – R&D get-togethers should be arranged periodically to bridge the communication gap.

v) The technology transfer agency and the licensing of technology should not be a one step transaction alike a photographer’s job, but technology transferring agency should endeavor to assist the licensee at all stages of commercialization.

vi) Industrial associations must play greater role in educating entrepreneurs/industrialists as regards promotion of indigenous technologies.

vii) Industries should organize in-plant training programmes in coordination with R&D agencies to develop technical capabilities for absorbing indigenous technologies.

8.4. General

i) Increasing recognition needs to be given to the concept of horizontal transfer of technology by evolving a suitable working mechanism for promotion, transfer and utilization of indigenous technologies. In this context, it may be mentioned that technology transfer organizations (s) may initially consider restricting the know-how transfer to one or two chosen entrepreneurs/industry instead of releasing to several parties. After successful absorption, adoption and development of the technology, it may be offered as a complete integral package to other prospective users especially to small scale industries. By this technique the transferring agency can effectively bridge the gap existing in the present technology transfer mechanism (between generators and users) necessary for successful promotion of indigenous technologies.

ii) A rigorous selection procedure must be followed to determine the fields of research in which a country can afford to specialize and make a significant contribution both to adopting imported technologies and to promote new technologies. Major activities should be directed to those vital and strategic areas where maximum value added can result in the overall transformation process.

iii) In the areas selected for R&D, a proper balance must be maintained between the efforts to digest imported technologies fo r the driving sector, and the development of new technologies for the future sector, resources must be allocated specifically for market research and commercialization of new and emerging technologies.

iv) Financial institutions should provide concessional finance and risk capital for the implementation of development projects based on research. They should develop policies and mechanisms for assisting entrepreneurs and industry not only for commercialization of technologies but also for post-production improvements. The development banks and financial institutions should adopt expeditious and simplified procedures, preferably in a packaged form, whether it is direct or through technology transferring agencies. There should be an exclusive cell to coordinate these activities, ensuring effective working relationship with user agencies. Similarly, these institutions should also be represented in the promotional organizations for active participation in technology utilizations.

v) Awards are mostly given for advancement of science and for promoting inventions. However, in most developing countries, successful commercialization of indigenous technologies are not well recognized and rewarded lucratively. This aspect needs special attention and positive encouragement for promoting technology utilization.

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