CHAPTER II

TECHNOLOGY POLICY FORMULATION IN DEVELOPING COUNTRIES:

with special reference to

Institutional Framework and Policy Development Process

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TECHNOLOGY POLICY FORMULATION IN DEVELOPING COUNTRIES

Contents

INTRODUCTION

This is an abridged and updated version of a report originally commissioned by the Commonwealth Secretariat in October 1984 to provide background material for members of the Commonwealth Working Group on the Management of Technological Change.

The report is in two parts. The first part defines certain terms and sets out the geographical coverage of the report. It then briefly surveys present policies and related institutional frameworks for promoting and facilitating technological change in selected Commonwealth countries at different stages of economic development. The second part looks to the future and discusses possible improvements to technology policies and other measures in order to enhance their operational efficacy in helping to fulfil the overall socio-economic goals of communities.

Because of time and other constraints the report had to be based on literature available within India. But bearing in mind the relative lack of development of science and technology policies in most countries, it is doubtful if a wider survey would have made a very great difference to the outcome of the report.

The author wishes to express his appreciation to the authorities concerned at the Planning Commission, Department of Science and Technology, Council of Scientific and Industrial Research, National Council of Applied Economic Research, NISTADS, United Nations, IDRC, British Council and other institutions in New Delhi for the library facilities availed to him. He is also grateful to Professor M.G.K. Menon, Member, Planning Commission and Chairman, Technology Policy Implementation Committee, Government of India, for guidance in preparing the report and to the Commonwealth Secretariat for entrusting him with the task. Finally, the author wishes to emphasise that all views expressed and suggestions made in the report are his own and do not necessarily represent those of the Technology Policy Implementation Committee or the Cabinet Secretariat of the Government of India, nor those of the Commonwealth Secretariat.

Part I

TECHNOLOGY POLICIES AND ECONOMIC AND SOCIAL DEVELOPMENT : THE PRESENT POSITION

Section 1

Definitions and Coverage

Definitions

The literature on science and technology (S&T) policy makes frequent use of certain expressions or phrases. Some of these are useful in the context of the present report and are defined below.

(i) "Science" can be considered as a systematic study aimed at the basic understanding of natural or social phenomena and the unravelling of cause and effect relationships involved.

(ii) "Technology" is defined in Webster's Seventh New Collegiate Dictionary as "a technical method of achieving a practical purpose" and "the totality of the means employed to provide objects necessary for human sustenance and comfort".

(iii) "Appropriate technology" has been defined by the UNIDO Second Consultative Group on Appropriate Technology as "that technology which contributes most to the economic, social and environmental objectives of development".

(iv) "Technological change" is defined by UNCTAD[1] as "an advance in knowledge and a change in technique, an alteration in the character of the equipment, product and organisation, which is actually being utilised". An alternative way of looking at technological change would be from the point of view of the changes which the introduction of a new technology brings about in a society. Some of these may be substantial, in terms both of economic well-being and of social or cultural values. In this sense,technological change would be the end-result of introducing a new technology into a society.

(v) "Science and technology (S&T) policy" most commonly refers not only to policies for developing S&T itself but more especially to policies designed to ensure that the development or application of technology fulfils pre-determined socio-economic or other goals of a community. According to that definition, the objectives of a country's S&T policy would have to be derived from its socio-economic, security or other goals which, in turn, might depend to some extent on the geo-political setting of the country.

(vi) "Absorption of technology" is generally used in connection with the acquisition of technology. It implies not only understanding and mastering the operational 'know-how' of processes and techniques, but also of attempting to understand and acquire the 'know-why' of the designs, techniques and processes relating to the operations involved, with the object of being able to alter them to suit local conditions and to make further improvements to them.

(vii) "Adaptation of technology" involves making imported technologies suitable for local materials, skills and markets.

(viii) "Technology assessment", as defined by one UN organisation, is a "process for the systematic analysis, forecasting and evaluation of a broad range of impacts on society pertaining to technological change and choice in order to identify public policy and options. It helps to match technological development to national goals".[2]

(ix) "Technology forecasting" has been defined by Martino[3] as "a prediction of the future characteristics of useful machines, procedures or techniques".

There are numerous other phrases like "applied research", "basic research", "research, design and development (RD&D)", which are frequently used in the literature. Most of these are defined in the "Frascati Manual"[4]: in other cases, their meanings are obvious from the context in which they are used.

Coverage

This first part of the report provides a brief overview of the state of S&T policies in four Commonwealth countries at varying stages of economic development. It concentrates on technology assessment, choice, transfer, adaptation, development and utilisation, and to the structural changes and adjustments needed within and between economies and societies in order to promote and facilitate technological change. The aim is to compare and contrast the evolution of S&T policy in the four countries, to examine the objectives and criteria used in determining those policies, and to evaluate the institutional framework for their implementation. This is followed by an assessment of the efficacy of S&T policies in these countries. Drawing on these experiences, the second part of the report presents a set of model policies, at both macro- and micro-levels, which could promote and facilitate technological change.

The selected countries are India, Bangladesh, Singapore and Tanzania, particular emphasis being given to India. They were chosen primarily because of their different economic and social characteristics - reflected in their diverse levels of per capita income (ranging from US$120 in Bangladesh to US$3,770 in Singapore) as well as in their different economic sizes and structures. Singapore, as a newly industrialising country, was selected to see how far its technology policies contrasted with those of the other three.

In three of the four countries (the exception was India), the absence of field visits and the non-availability of up-to-date documents on their technology policies meant that the survey of these countries' S&T policies and institutional mechanisms was largely based on their papers prepared for the United Nations Conference on Science & Technology for Development (UNCSTD) held in Vienna in August 1979. In addition, use was made of a 1982 UNCTAD report entitled "Technology Policy in the United Republic of Tanzania : Survey of Issues and Recommendations for Action".[5]

Section 2

Objectives of S&T Policies and Criteria for Determination

As already mentioned, the objectives of national S&T policies should be decided in the light of a country's socio-economic and other goals and its geo-political setting. It should also be possible for countries to agree internationally on certain common objectives, such as the development of technologies to satisfy basic human needs. Unless S&T policies have well defined objectives both at the national and the international level it is likely that the development of new technologies will continue to be determined largely by 'market-pull'. As a large part of the world's population is too poor for their basic needs to be adequately reflected in the form of 'market demands', technological developments, left to their natural forces, generally fail to satisfy these needs, particularly of people living in developing countries. It is therefore imperative that these countries define their S&T policies with clear objectives and priorities determined in the light of their socio-economic and other developmental goals.

Since the beginning of the 1970s many developing countries, both within the Commonwealth and outside, have recognised this need. India, however, seems to be one of the few which has made an explicit statement of its S&T policy in recent years. In most other countries there is an implicit S&T policy, which can be derived from their decisions, practices and mechanisms relating to technology imports, technology development, sectoral allocation of resources for R&D, diffusion policies, labour and manpower development policies, and socio-economic goals. Bangladesh, Singapore and Tanzania all fall into this category.

The present section surveys the objectives of the explicit/implicit technology policies in these four countries. It focuses on the policy development process in terms of the assessment, choice, transfer and absorption/ adaptation of imported technologies, the development and utilisation of indigenous technologies, and the structural adjustments needed to promote technological change. The institutional framework adopted by these countries for implementing their S&T policies, e.g. for the regulation of technology imports, technology development and technology diffusion, is described later (page 175).

INDIA

Evolution of science & technology policy

One of the earliest official documents on S&T in India was the Government of India's Scientific Policy Resolution (SPR) of March 1958. This set out the major aims of the Government's S&T policy as follows:

(i) to foster, promote and sustain, by all appropriate means, the cultivation of science, and scientific research in all its aspects - pure, applied and educational;

(ii) to ensure an adequate supply, within the country, of research scientists of the highest quality and to recognise their work as an important component of the strength of the nation;

(iii) to encourage and initiate, with all possible speed, programmes for the training of scientific and technical personnel, on a scale adequate to fulfil the country's needs in science and education, agriculture and industry and defence;

(iv) to ensure that the creative talent of men and women is encouraged and finds full scope in scientific activity;

(v) to encourage individual initiative for the acquisition and dissemination of knowledge, and for the discovery of new knowledge, in an atmosphere of academic freedom; and

(vi) in general, to secure for the people of the country, all the benefits that can accrue from the acquisition and application of scientific knowledge.

Since 1958 scientific activity in India has expanded considerably. India now has a substantial infrastructure of S&T institutions and capabilities in a wide variety of fields including agriculture, health, defence, atomic energy, space, oceanography, electronics and various industries.

The second important document on S&T policy was produced by the National Committee on Science and Technology (NCST) in connection with the formulation of the first S&T Plan for India. An Approach to the Science & Technology Plan (January 1973)[6]. dealt with the contemporary status of S&T policy in India, the strategy for S&T in national development, areas of prime importance for India in S&T planning, as well as other issues related to organisational and managerial reforms and finance. One of the document's suggestions was that the public and private sectors should be encouraged to use indigenous sources of technology. It also urged the Government to draw up an S&T policy with a commitment to use all public policy instruments to promote national enterprises whose control lay in Indian hands, and to direct policy choices to the use of domestic natural and human resources even if this involved short-term costs. The report further suggested that to be really effective, a technology policy statement should cover such diverse subjects as the development and regulation of industry; the pricing of capital; the lending policies of public financial institutions; the relative pricing of indigenous and imported raw materials and intermediates; and the regulation of brand-names and patents, industrial standards and technical and commercial guarantees. Finally, it was suggested that the general thrust of the S&T Plan should be to motivate the nation to follow the 'swadeshi' (self-reliance) road and to bring about the changes needed to make the use of domestic industrial technology more attractive for public or private entrepreneurs.

Technology policy statement

In keeping with the suggestions in the NCST document, the Government produced a 'Technology Policy Statement' (TPS) in January 1983[7]. This defines the basic objective of India's S&T policy as the development of indigenous technology and efficient absorption and adaptation of imported technology appropriate to national priorities and resources. These broad objectives have been divided into various aims as follows:

(i) to attain technological competence and self-reliance, reducing vulnerability, particularly in strategic and critical areas, and making the maximum use of indigenous resources;

(ii) to provide the maximum gainful and satisfying employment to all strata of society, particularly women and the weaker sections of society;

(iii) to use traditional skills and capabilities, making them commercially competitive;

(iv) to ensure the correct mix between mass production technologies and production by the masses;

(v) to ensure maximum development with minimum capital outlay;

(vi) to identify obsolescence of technology in use and arrange for its modernisation;

(vii) to develop internationally competitive technologies, particularly those with export potential;

(viii) to improve production through greater efficiency and fuller utilisation of existing capabilities, and enhanced quality and reliability of performance and output;

(ix) to reduce the demand for energy, particularly from non-renewable sources;

(x) to ensure harmony with the environment, preserve the ecological balance and improve the quality of the habitat; and

(xi) to recycle waste materials and make full utilisation of by-products.

Priority areas for technology development identified in the TPS are:

(i) agriculture, including dry-land farming;

(ii) optimum use of water resources, increased production of pulses and oilseeds;

(iii) provision of drinking water in rural areas, improvement of nutrition, rapid reduction in the incidence of blindness, eradication of the major communicable diseases (such as leprosy and tuberculosis), and population stabilization;

(iv) low-cost housing;

(v) development and use of renewable non-conventional sources of energy; and

(vi) industrial development.

Technology import policy

While recognising that a policy directed towards technological self-reliance does not imply technological self-sufficiency, the TPS emphasises that imports of technology shall not be at the expense of the national interest and that indigenous initiative must receive due recognition and support. It states that in the acquisition of technology, consideration will be given to the choice and sources of technology, alternative means of acquiring it, its role in meeting a major felt need, relevance of the products, costs, and related conditions. It is further stated that where the import of technology is contemplated, the level to which technology has been developed, or is in current use, within the country, shall first be evaluated. Lists of technologies that have been adequately developed to the extent that imports are unnecessary shall be prepared and periodically updated. In such areas, no import of technology shall normally be permitted and the onus will be on the seeker of foreign technology to demonstrate that imports are necessary. An acceptable case, for instance, may be where the technology does not exist in India and the time taken to generate it indigenously would delay the achievement of development targets. The Government may identify areas of high national priority, in respect of which procedures would be simplified to ensure timely acquisition of the required technology: where such imports are allowed, importers are required to take measures to ensure that the imported know-how is absorbed, adapted and developed.

Unpackaging of technology

The TPS also suggests that as the total package of (imported) technology required for any purpose can be broken down into several components. Some of these may be readily available or indigenously developed and others may need to be imported. It is necessary to evolve norms and guidelines for such unpackaging of technology, with a view to maximising the use of domestic technological capabilities and reducing expenditure of foreign exchange on unnecessary technology imports.

Technology assessment and choice

The TPS stipulates that the existing technology assessment systems will be reviewed and that a mechanism consisting of competent groups will render advice in all cases of technology import relating to highly sophisticated technology, large investments, and national security. It further suggests that while assessing a technology for purposes of import, aspects of employment, energy, efficiency and environment will be kept in view. Further detailed guidelines for technology assessment were being evolved in October 1985.

Absorption and adaptation of imported know-how

The TPS stipulates that investment in indigenous R&D should be on an adequate scale for the absorption, adaptation, improvement and generation of new technology. While mechanisms for ensuring the meaningful absorption and adaptation of imported technology are currently being developed, many Indian enterprises are already devoting a substantial part of their R&D expenditure to the absorption of know-how, adaptive research and similar 'defensive' R&D activities.

Role of foreign capital

Foreign investment in India is generally permitted only if it brings sophisticated technology or is intended for export-oriented projects. However, there are two exceptions: first, under the Foreign Exchange Regulation Act, equity investments of up to 40 per cent of the total are permitted in priority and export sectors. Secondly, liberalised facilities have been provided for non-resident Indians making portfolio investments in India. Foreign investment up to 74 per cent of the total is also permitted in cases where the technology is highly sophisticated or is oligopolistically held and up to 100 per cent where the project is wholly export-oriented.

Guidelines for foreign collaboration

The government has laid down comprehensive guidelines for foreign collaboration[8]. The duration of foreign collaborations is, ordinarily, restricted to eight years from the date of the agreement. The payment of royalties to the collaborators is normally permitted for five years from the date of starting commercial production, although in exceptional cases up to ten years has been approved. Royalties and other fees to foreign collaborators for know-how are ordinarily restricted to 5 per cent of domestic sales, but rates of up to 7 per cent or more are considered for export-oriented projects. Where royalty and lump sum payments go together, the guidelines require the total payment to the collaborator to be restricted to 8 per cent of the value of production for a base period of five years, although higher limits have been allowed in special cases. The guidelines specifically restrict the incorporation in foreign collaboration agreements of any clauses which prevent the use of know-how or technical information for the manufacture of the products in question by the licensee on expiry of the agreement. Likewise, clauses requiring the licensee not to disclose the information in his possession to third parties after the term of the agreement are not allowed. Clauses requiring the technology purchaser to acquire machinery, equipment, materials, components or services only from the licensor or from other sources specified by him are also normally not allowed, nor are clauses restricting the direction of manufactured exports. Repetitive purchases of the same technology by different entrepreneurs or renewals of foreign collaboration on the expiry of their normal term are generally discouraged, the latter being with a view to compelling the Indian parties to take steps to absorb the foreign technology within the agreement period.

Development, promotion and utilisation of indigenous technology

The TPS also provides detailed guidelines on the development, promotion and utilisation of indigenous technology. The fullest support is to be given to the development of indigenous technology, to achieve technological self-reliance and reduce the dependence on foreign inputs, particularly in critical and vulnerable areas and in high value-added items in which the domestic base is strong. At the same time, strengthening and diversifying the domestic technology base are necessary to reduce imports and expand exports, keeping in view international competitiveness.

In order to foster invention and innovation, the TPS suggests the institution of a system of rewards and incentives to inventors (both individuals and enterprises), along the lines of the existing 'Independence Day' and 'Republic Day' Awards to notable inventors through the National Research Development Corporation of India. National awards from the Ministry of Industry are also recommended for major breakthroughs in import substitution.

The TPS draws attention to the need for upgrading and enhancing India's traditional skills and capabilities by using the knowledge and techniques of modern S&T. It envisages special support to technologies which result in low-cost production, less use of scarce items and greater use of local raw materials and resources, and marketability of products close to the point of production.

In view of the long period usually required for developing new technologies, the TPS calls for the early identification of relevant technologies in all priority areas, particularly where large investments or large-scale production are envisaged. After identification, it is necessary to fix time schedules, select institutions to implement the project, and ensure the provision of timely and adequate finances to complete it.

The Planning Commission Steering Group on Science and Technology, set up in connection with the formulation of India's Seventh Five Year Plan (1985-90), has accordingly suggested[9] the institution of a system of selective 'technology missions' to be activated in the industrial and other sectors during the Seventh and subsequent Plans. It has in addition emphasised the need to ensure proper linkages not only between different organisations and institutions engaged in research, production and related activities, but also between policies for indigenous technology development and those for technology import, so as to ensure that the utilisation of the results of 'technology missions' is not pre-empted by the import of foreign technology, leading to wastage of scarce resources on R&D.

In order to increase demand, the TPS has proposed the provision of incentives to users of indigenous technology and for the resulting processes and products. Policies already exist for granting preferential licences to products made substantially with indigenous technologies developed in recognised industrial R&D establishments and for delicensing the manufacture of products from technologies developed in national laboratories.

The TPS has emphasised the role of design engineering consultancy organisations in bridging the gap between laboratory-scale R&D and commercial production, and in promoting the utilisation of indigenous materials and equipment. It has suggested that the capability for total systems engineering, process development and project management should be developed, with foreign collaboration if necessary. It has also stressed the need for strengthening and upgrading design engineering capabilities and promoting Indian engineering consultancy, both in the public and the private sectors, on a sound professional basis.

The TPS considers in-house R&D units in industry to be an essential link between activities in national laboratories and production in industry. Accordingly, it has been suggested that appropriate incentives should be given to set up R&D units in industry, including those on a cooperative basis. Enterprises will be encouraged to set up units of a size which permits the accomplishment of major technological tasks.

Technology diffusion and transfer

The TPS refers to the need for making special efforts to ensure the diffusion of existing technology to all who can employ it well. Appropriate measures may include horizontal transfer, technological support for ancillaries of large units, technology inputs to small units, and upgrading traditional skills and capabilities.

The TPS recognises the need to maintain international competitiveness and standards in products, services and technologies that have export potential. Thus, conditions for marketing indigenous technology and resultant products may have to be improved. In order to promote technology exports, income tax exemption is allowed on half of any income received by an Indian company or from a foreign company or government for an invention, model, design, formula, process or some other form of industrial, commercial or scientific know-how or technical service.

The vertical transfer of know-how from R&D or academic institutions to industries in India is promoted primarily through the National Research Development Corporation (NRDC) by non-exclusive licensing of know-how on payment of a lump-sum fee coupled with recurring royalties at varying rates for specified periods. The NRDC also provides 'risk finance' for up to half the costs of 'development projects' to selected industries where a pilot plant, proving plant or prototype development facility is considered necessary to scale-up the laboratory-level know-how or to bridge the gap between laboratory-scale work and commercial activity. If the project is successful, the NRDC recovers its outlay as a soft loan; if it is not, then the NRDC's share of the cost is written off.

Structural change and adjustment

India's major experience of structural change and adjustment in response to technological transformation has arisen in connection with:

(i) the application of modern technology in the agricultural sector;

(ii) the promotion of health and family welfare programmes through adoption of new techniques; and

(iii) the introduction of computers in many organisations and institutions.

In agriculture, it was found that an absentee-landlord system, with a large number of tenant farmers, tended to discourage the investment in modern inputs (improved seeds, fertilisers, associated equipment, etc.) needed to raise productivity. The land-tenure system was therefore restructured throughout the country. Likewise, all state governments implemented laws in the 1950s and 1960s to consolidate land-holdings belonging to individuals and prevent their fragmentation below an economic size through sale or inheritance. Consolidation helped farmers to achieve economies of scale (within the limits of 'land-ceilings', which were simultaneously imposed for socialist reasons) associated with the use of modern technology and to raise their productivity. At the same time, farmers' rural services and credit cooperatives were set up to organise the supply of agricultural inputs and credit at the village level. Lastly, community development activities such as agricultural extension and social education were promoted by the creation of non-official institutions at the level of the village, taluk, and district, which provided a mechanism of two-way communication between local communities and government.

In the promotion of preventive and diagnostic medicare and the introduction of new methods of family planning, 'Mahila Clubs', 'Youth Clubs' and other voluntary bodies have been extremely effective. Such groups distribute the more common medicines or simple family planning devices, etc., among the target population of remote areas, and have greatly facilitated implementation of Government health and family welfare programmes.

Finally, the introduction of computers (and many other radical or new technologies) in various industries, organisations and institutions has illustrated the great value of prior and meaningful consultations between management and workers' unions. Consultations have helped to reduce workers' apprehensions about the possibility of job losses or other negative effects of introducing new technologies and have thereby assisted in avoiding strikes, lock-outs, etc. It is, however, still too early to assess the outcome of the Government's new computer policy (see page 178 below), which was promulgated in November 1984.

At the national level, the Government has recently set up the National Council for Science and Technology Communication (NCSTC) to popularise S&T and inculcate a scientific ethos among the people[10]. The NCSTC has proposed that it should run training and orientation programmes for S&T communicators, monitor and evaluate S&T popularisation activities and tools, set up a National S&T Information Bureau, produce software for various forms of mass-media, and coordinate and orchestrate existing activities in this field. Such activities, in collaboration with those of various State Governments, voluntary agencies and other organisations, should greatly ease the task of transforming the technological basis of Indian society.

BANGLADESH

Objectives and priorities of science and technology policy

In the second Five Year Plan (FYP), instituted in July 1980, the Government of Bangladesh gave the highest priority to economic growth, employment generation and population control. It has done so primarily through the development of agriculture and the rural economy, which absorb large numbers of workers but have low output-capital ratios. In industry, emphasis has been placed on better utilisation of productive capacity and higher operational efficiency, as well as on more efficient utilisation of indigenous natural resources.

The country has given high priority to the application of S&T for achieving its development objectives and has set up various S&T policy, planning and executive organs. Principal among these are the National Council for Science and Technology (NCST), and the Science and Technology Division (S&TD); both are headed by the President, who is assisted by a Science Adviser.

The NCST, after undertaking an assessment of national needs, has prepared a National Plan for Science and Technology as an integral part of the FYP. Its main policy guidelines and priorities are as follows[11].

Main policy guidelines for S&T development

(i) to create a climate favourable to the development of S&T;

(ii) to develop an S&T capability to generate, select, adapt, absorb, use, maintain and operate technology;

(iii) to identify national needs where S&T are to be applied for socio-economic development, and to tailor S&T to these needs, particularly in the area of food, population control, education, health and housing. Some basic research is also essential to keep abreast of S&T development in the outside world;

(iv) to identify the most appropriate technologies for utilising major indigenous resources (people, minerals, soils, climate, etc.);

(v) to develop close interaction and cooperation between scientists/technologists, and planners, policy-makers and leading business executives;

(vi) to link S&T development to an effective manpower plan and to integrate it into the overall national development plan;

(vii) to develop close links between producers and users of technology; and

(viii) to generate a capacity for innovation among ordinary citizens and to give them the means and self-confidence to demonstrate their new ideas.

S&T priorities

(i) to strengthen education and training facilities for the creation of:

(a) middle-level technicians and skilled workers using technologies associated with 'basic needs' goods and services;

(b) professionals, technicians, managers and skilled workers to apply advanced technology; and

(c) high quality manpower to conduct and manage R&D and engineering works in scientific and technological institutions and supporting facilities;

(ii) to strengthen institutions for undertaking R&D on selected areas related to development objectives. Top priority would be given to engineering and the capacity for generating indigenous technology;

(iii) to promote effective design and engineering consultancy services;

(iv) to strengthen extension services, particularly in selected areas;

(v) to strengthen the information and documentation system and promote scientific and technological communication;

(vi) to promote the application of S&T for integrated rural development;

(vii) to intensify prospecting for and development of natural resources, prepare an inventory of such resources and to make efficient use of them;

(viii) to establish a National Centre for the Transfer and Development of Technology (NCTDT); and

(ix) to set up an institution for the domestic innovation and commercialisation of technology - the National Research Development Corporation (NRDC).

Because the Government of Bangladesh has given high priority to the development of food and agriculture, water resources, industry, energy, physical infrastructure and family planning, it should give corresponding priority to the acquisition or development of technology in these areas and make resource allocations accordingly.

Technology assessment and choice

Bangladesh does not yet seem to have effective criteria or institutional mechanisms to assess and select foreign technologies appropriate to its needs. Lack of domestic savings and foreign exchange have retarded its industrial growth, and the climate for its acquisition of technology through investment from other countries has not been very encouraging. Most projects based on imported technology have been turn-key in nature and the supply of capital goods has been financed largely through tied credits. In addition there have been three major and related internal constraints to the choice of technology. First, a lack of skilled and experienced individuals to make optimum decisions; second, inadequate national programmes or centres to provide the necessary information, training and extension services to identify, acquire, adapt and develop technology appropriate to local conditions; and third, insufficient local capital to fund such developments.

Role of foreign capital

In its revised industrial policy, the Government recognises that foreign investment can play an important role in Bangladesh. It considers that foreign investment should bring in not only technical know-how but also managerial skills and access to R&D and operational experience. Bangladesh now offers a number of financial and fiscal incentives to foreign private investors, including capital participation, repatriation and remittance facilities, compensation guarantees, and tax concessions. There are several other concessions applicable to both local and foreign investors, including rebate of import duties, services of utilities and credit facilities. Finally, the interests of foreign investors are protected by various laws.

Foreign technology absorption and adaptation

In view of the small amount of in-house industrial R&D in Bangladesh and the inadequacies of the S&T infrastructure, the prerequisites to foster and support a capability to absorb and adapt imported technologies are still largely to be developed.

Indigenous technology development, promotion and utilisation

Bangladesh is actively building up its infrastructure for the development, promotion and utilisation of appropriate indigenous technologies, as part of its strategy of self-reliant development.

Research institutions and universities are being built up for this purpose and their links with industries, government and other users are being strengthened. The proposed NCTDT should act as a focal point, providing information, training, consultancy and extension services, and strengthening capacities to select and negotiate technology imports, to unpackage technologies selected, and to decide which components should be produced domestically and which should be imported.

Technology policy development

Bangladesh is evolving a technology policy which envisages specific measures to narrow the technological gaps between the modern formal sector, and the traditional informal urban and rural sectors. In particular, the new R&D institutions are intended both to adapt imported technologies to make them suitable for local needs and to develop new technologies in keeping with the factor endowments of the country.

'Appropriate technology' is conceived by Bangladesh as a dynamic concept. Both labour-intensive and capital-intensive technologies are considered appropriate, but in different circumstances. A reasonable balance between the two is needed to maximise economic growth, employment and the satisfaction of basic needs, with capital as a major constraint. The Government recognises that technology choice must take account of working conditions and the environment. In addition it acknowledges that factor price distortions can lead to the selection of inappropriate technologies. Thus, to make an optimal choice of technology, there may have to be adjustments in policies affecting wages and prices, foreign exchange rates, taxes, interest rates, licensing, and resource allocation.

The Government envisages that for each project, the choice of technology will be specified and justified in terms of the major objectives of the FYP. The planners will be required to ensure compatibility between the country's technology mix and its socio-economic objectives. The Bangladesh technology policy will guide not only planners and those who choose technology, but also those who are concerned with the legal and financial aspects of the transfer of technology, who adapt or develop technology, and who are responsible for its eventual application.

The policy will also cover measures for training specialists in technology choice, transfer and development, in which respect educational programmes may need to be re-oriented to ensure that more students acquire relevant skills. It will in addition encourage and make provision for R&D to diminish the country's dependence on imported technologies. At the same time, technology users will be assisted with identifying, procuring and applying the most suitable technologies.

Structural change and adjustment

The Government believes that the technological transformation of Bangladesh society will depend on the nation-wide popularisation of S&T. The NCST has launched several programmes to attain this goal, including:

(i) supporting non-governmental S&T organisations, such as the Bangladesh Science Academy, the Bangladesh Association for the Advancement of Science, and the Bangladesh Institute of Engineers;

(ii) establishing a National Science and Technology Museum;

(iii) organising S&T clubs in educational institutions;

(iv) holding S&T exhibitions;

(v) instituting a 'National Science Week'; and

(vi) arranging lecture tours by scientists and technologists.

The Government also recognises that the technological transformation and successful development of rural areas hinges on the creation of appropriate and effective rural institutions, which must be organised to ensure popular participation in development activities, and the efficient delivery of supplies and services in rural areas. With that in mind, a National

Centre for Rural Technology has been established in the Bangladesh University of Engineering and Technology. In addition, rural technology extension services and training facilities are being built up for the promotion and management of rural industries (both on a cooperative and private basis). A number of village technology centres are also being set up to help maintain and repair new tools, machinery and equipment, as well as assisting with training, extension and other services.

SINGAPORE

Objectives and criteria of technology policy

The Government of Singapore believes that the foundation of a modern society must be based on the application of S&T to economic and social activities. To promote technological change, and thus economic growth, it pursues various policies of an essentially catalytic nature. These include the provision of infrastructure, scientific and technical manpower, R&D, supporting institutions, and investment incentives.

There have been three phases in the development of technology policy in Singapore. The first phase (1960-69) laid the foundation for industrial growth by the drastic restructuring of the country's political, economic and social systems. In response to the problem of unemployment exacerbated by a rapidly expanding population, the Government launched an industrialisation programme. This sought to create a more just and equal society, to increase job opportunities, to diversify the economic base from trading and mercantile activities to include manufacturing and service activities, and to provide workers with better training and education. Initially, the Government sought to tackle unemployment through the development of labour-intensive and import-substitution industries. Following Singapore's separation from the Federation of Malaysia in 1965, and the reduction of its domestic market, the limitations of this policy became obvious and the Government began to encourage a shift from import-substitution to export-promotion activities. During the second phase (1970-79), Singapore policies laid emphasis on high-technology, skill-intensive and high value-added industries, producing goods for the world market. As manpower shortages emerged, the emphasis shifted to more capital-intensive industries. Substantial incentives were offered to foreign investors in technology-intensive and high value-added industries, while existing industries were encouraged to upgrade their production technology. The Government also participated directly in the new industries, particularly where there was little capital investment from other sources. Lastly, entrepreneurs were encouraged to raise productivity to increase the competitiveness of Singapore's goods and services in world markets. In the third phase, which began in 1980, the Government has continued to pursue most of the policies and programmes adopted during the second phase. But in addition it has begun to develop the country's design capability in various engineering fields, and so reduce dependence on imported designs and increase the technical sophistication of local industries. Other long-term objectives include the use of S&T to solve a host of socio-economic problems. For instance, the Government is interested in the development of non-conventional energy sources and in the use of coal and nuclear energy to supplement oil; also with water desalination and environmental control, particularly the problem of waste disposal.

Role of foreign capital

A large number of foreign firms have set up operations in Singapore attracted by numerous investment incentives, the favourable infrastructure and availability of skilled personnel, as well as by the Government's belief in free enterprise, whether foreign or domestic. In 1977, foreign firms and foreign-controlled joint ventures together accounted for 23 per cent of the establishments in Singapore, 55 per cent of the employment, 65 per cent of the value-added in manufacturing and 85 per cent of the direct exports[12]. These foreign interests have played an important role in the modernisation of Singapore's economy.

Technology imports

In Singapore there are no administrative or legislative controls over technology acquired under licensing agreements. Instead the choice is left to the discretion of entrepreneurs. Technology and skills are also transferred to Singapore by joint ventures and foreign companies' subsidiaries.

As well as the incentives already mentioned, the Government has set up a special fund to meet the financial needs of foreign and local companies establishing technology-intensive manufacturing operations in Singapore. It may also invest up to half of the equity in new ventures, with the provision that this investment may be sold after the venture is operating successfully.

Technology assessment and choice

The Government has not established any specific mechanisms to assess and choose technologies. However, since the late 1960s it has encouraged high-technology and high value-added industries. Between 1965 and 1976, the proportion of value-added in Singapore's manufacturing industry accounted for by high value-added activities (e.g. electronic products, precision equipment) rose from 42 per cent to 72 per cent, whereas that contributed by low value-added activities (e.g. food, garments, leather products) fell correspondingly[13].

Indigenous technology development, promotion and utilisation

To stimulate indigenous R&D the Government has established various institutions and professional organisations, which are discussed below (page 181). R&D by the foreign-owned or controlled corporate sector in Singapore is largely concerned with product or process adaptation or application rather than with innovation as such. Many local firms, on the other hand, do perform R&D into new product or process design and development.

The Government exercises little control over industrial R&D. However, the Economic Development Board provides financial assistance under its 'Product Development Scheme' to industries undertaking R&D locally, with priority for products meeting criteria such as technological sophistication, export competitiveness and financial viability.

Structural change and adjustment

In order to promote the country's technological transformation, the Government has followed both promotional and interventionist policies. Numerous incentives have attracted foreign firms, including TNCs, which have brought with them the capital and advanced technological resources essential for Singapore's economic and social development. The realisation of local technological capabilities has also been encouraged by Government through institutional and financial support. However, "Most important of all in stimulating private foreign and local investment in manufacturing were the continuing political stability under the People's Action Party regime, its success in eliminating labour unrest and reducing strikes to minor proportions, and its generally even-handed regulation of trade-union and management relationships to prevent production costs and export prices from rising too fast compared to those of Singapore's competitors"[14].

During the late 1960s, enactment of the Employment Act (1968) and the Industrial Relations (Amendment) Act (1968) meant that after a long struggle, the Government appeared to have achieved a greater degree of control over the labour force and labour costs. The absence of labour militancy in Singapore remains an important factor in attracting foreign investment, and in promoting technological growth and social transformation.

TANZANIA

Technology policy evolution

The evolution of technology policy in Tanzania, like other countries, has been intimately related to its socio-economic goals and priorities as spelt out in its Five Year Plans (FYP) and in the Arusha Declaration. The major goals of its first FYP (1964-69) were:

(i) rapid growth of modern industry, *inter alia*, to raise productivity;

(ii) massive expansion of the education system;

(iii) increase in national savings and investment;

(iv) enhanced economic role for Government;

(v) modernisation of the agricultural sector; and

(vi) expansion of intra-African trade and economic cooperation.

In 1967 the Government issued the Arusha Declaration. This had five main themes:

(i) public control over large parts of the economy, viz. financial institutions, large-scale industry and commerce, and large-scale estate agriculture;

(ii) development through self-reliance, i.e. the decentralised domestic mobilization and use of local resources;

(iii) priority for the rural sector;

(iv) creation of a socialist society, primarily through cooperative production under the 'Ujamaa Programme' of collective ownership and community production in agriculture, and through nationalisation of key industries in the modern sector; and

(v) the creation of social equality, particularly by narrowing the gap in income levels, particularly between the rural and urban sectors.

Following the re-orientation of policies after implementation of the 'Arusha Declaration' and the FYPs the country developed a capacity to produce mass consumer goods, including food beverages, footwear and cloth as well as some intermediate goods like fertilisers, cement and rubber products. For a time prospects appeared good, but later internal economic difficulties and external shocks, such as the two oil price rises, led to setbacks which were exacerbated by the absence of a fully effective policy for technology. This lacuna has been reflected in part by the disappointing performance of both the agricultural and the industrial sectors and by the general lack of a technically skilled cadre.

Technological dependence

Tanzania continues to be largely dependent on foreign technology, much of it aid-financed. Imported technology is acquired through agreements, embodied in intermediate and capital goods, and through the use of expatriate personnel. Foreign direct investment is not a major channel for technology acquisition; foreign equity is permitted in industrial projects, but private foreign investment has been limited. The Government requires majority local ownership in joint ventures; but other conditions are flexible, negotiated project by project and varying from one sector to another, depending on national priorities.

When an enterprise wishes to import technology, it so decides; all that is required from Government is approval to acquire and use the foreign exchange. For new projects, there are elaborate procedures; but they relate not so much to the technology as such as to the costs and benefits of the project as a whole,and to its importance relative to national priorities. Such procedures may entail convening an inter-ministerial committee and approval by the Economic Committee of the Cabinet. Once approved, the task of deciding the nature and source of the technology required is normally left to the discretion of the ministry or parastatal. The inter-ministerial committees are concerned with the financial rather than the technological aspects of proposed agreements.

Normally in technology import negotiations, the Government involves representatives of institutions directly or indirectly concerned with financial and legal implications of a particular transaction. The National Development Corporation, a holding company which was set up in 1965 as the Government's main instrument of industrial development, has worked out a model management/technical agreement to serve as a guide to its many subsidiaries in the manufacturing sector.

Indigenous technology development and utilisation

The first important step towards developing indigenous technology in Tanzania was the establishment of the National Scientific Research Council (NSRC) in 1968. The NSRC's functions include:

(i) coordinating scientific research;

(ii) advising the Government on priorities for the allocation of research funds, scientific education, training and recruitment of research personnel, and the initiation, formulation and implementation of research policies and programmes;

(iii) promoting the documentation and dissemination of information; and

(iv) undertaking research in a variety of fields.

The NSRC operates through various working committees covering areas like food and nutrition, agriculture, building and construction, energy, medicine, scientific education and manpower, natural resources and natural sciences, and social sciences. It also has close links with the University of Dar-es-Salaam, which undertakes fundamental research in geology and other scientific fields. The NSRC has sponsored many basic research projects, and has set up the Tanzanian Research Information Service (TANRIS), whose main object is to promote the collection and dissemination of research results and information.

Over the last decade or so, a number of other organisations concerned with industrial promotion, advisory services and training have come into existence, mostly sponsored by the Ministry of Industry. Many of them have shown an increasing awareness of the importance of adapting and applying technology to local conditions. Among these organisations are: the Small Industries Development Organisation (SIDO) established in 1973; the Tanzania Industrial Studies and Consulting Organisation (TISCO)established in 1977; the Tanzania Manufacturing and Design Organisation (TEMDO); and the Tanzania Agricultural Machinery Testing Unit (TAMTU). In 1979 a new act established the Tanzania Industrial Research and Development Organisation (TIRDO). This is setting up a multi-branch Industrial Research and Services Institute (IRSI), with laboratories and pilot production facilities as well as testing and advisory services operating on a fee payment basis. The major divisions to be established in IRSI during the course of the country's 20 year Industrial Development Plan include: fibres; chemicals; engineering; food; and documentation.

The aim is to create a national system for domestic adaptation and development of technology. As yet, however, there does not seem to be any clear-cut technology policy with regard either to import or to the development and utilisation of domestic technology.

Structural change and adjustment

The most significant social step to facilitate and promote technological change has concerned education and manpower development. At the time of independence, the Tanzanian heritage of skilled manpower was quite meagre, and from the outset, the Government regarded educational and manpower development as a major instrument in achieving its social and economic goals. A policy statement by the Ministry of National Education in 1966 laid down that all employers must have a Tanzanian in training for every expatriate employee. Inadequate numbers of qualified Tanzanian candidates made this difficult to implement, however, and in the 1970s dependence on expatriates increased despite major efforts in education and manpower development. There continues to be an acute shortage of qualified persons in such fields as medicine, science, engineering and administration. The number of qualified persons continues to be insufficient to effect the structural changes in society needed to facilitate and promote technological change on an adequate scale for development.

Section 3

Institutional Framework for Implementation

INDIA

Indigenous technology development

Prior to independence in 1947, a number of notable S&T institutions existed, including the India Meteorological Department, Indian Research Fund Association (now Indian Council of Medical Research), Imperial Council of Agricultural Research (now Indian Council of Agricultural Research), and Council of Scientific and Industrial Research. In addition there were 20 universities. Since independence, an extensive institutional network has been set up. It includes the Atomic Energy Commission; University Grants Commission; Defence Research and Development Organisation; Space Commission; Electronics Commission; Research, Design and Standards Organisation of the Indian Railways; and the Telecommunications Research Centre. Many scientific departments have been established, including the Departments of Atomic Energy, Electronics, Space, Science and Technology, Agricultural Research and Education, Ocean Development, Environment, Non-conventional Energy Sources, and Scientific and Industrial Research. In addition there are nearly one thousand in-house R&D establishments in public/private sector industries and a large number of private scientific research foundations. A majority of these are engaged in applied R&D on industrial activities. The S&T departments of universities, institutes and colleges of higher technical education undertake R&D on basic and applied sciences and engineering. There are also numerous technical service/support/survey institutions, such as the Indian Standards Institution, National Test House, Botanical Survey of India, Zoological Survey of India, Small Industries Service Institutes, and Indian National Scientific Documentation Centre.

Many polytechnics and industrial training institutes located at district and sub-district levels train manpower skills for supervisory and operator jobs. Finally, many State Governments maintain research institutions and have set up State Councils of Science and Technology. All these activities form an integral part of the national S&T endeavour, overseen by the Planning Commission which considers S&T plans as an integral part of the country's socio-economic plan.

Various bodies have been set up to provide the highest levels of Government with scientific advice. The current body - the Science Advisory Committee to the Cabinet (SACC) - was established in 1981. It is serviced by the Department of Science and Technology, and has the following terms of reference:

(i) to advise on the formulation and implementation of Government S&T policy;

(ii) to identify and recommend measures to enhance the country's technological self-reliance;

(iii) to consider policy issues relating to the development and application of S&T which are referred to it by the Prime Minister or the Cabinet Committee on S&T;

(iv) to consider organisational aspects of S&T, including measures to provide adequate linkages between the scientific community, educational institutions, R&D establishments, industry and government; and

(v) to consider filling critical gaps in national competence, promoting technical cooperation among developing countries, and other issues concerning science in international relations.

In 1983, on the basis of SACC's recommendations, the Government set up the Technology Policy Implementation Committee, to facilitate and oversee implementation of its Technology Policy Statement made in January of that year. In January 1985, it established a National Microelectronics Council, to formulate, periodically update and review an integrated national plan for microelectronics (covering technology R&D, production, application, etc.), and to take decisions on all proposals for foreign collaboration and assistance in this area.

Technology import

As already mentioned (page 161), relatively high levels of foreign equity capital are permitted (under the Foreign Exchange Regulation Act (FERA) of 1974) in projects which have highly sophisticated technology (74 per cent) or are wholly export-oriented (100 per cent).

An inter-departmental committee under the Ministry of Finance is responsible for clearing cases under FERA. All technology imports under foreign technical or financial collaboration agreements are normally cleared by the Foreign Investment Board (FIB) set up in 1969 under the Ministry of Finance, though where imports of capital goods and industrial licensing are also involved, the Project Approval Board (PAB) set up in 1973 under the Ministry of Industry can grant a consolidated clearance. Both FIB and PAB examine such cases in consultation with the Departments of Industrial Development, Economic Affairs and Scientific and Industrial Research, the Directorate General of Technical Development, the relevant Ministry and other concerned organisations. Where necessary, the PAB also obtains advice from the Technical Evaluation Committee (TEC) set up in 1976 under the Chairmanship of the Director General of Technical Development, which examines the availability of indigenous technology and the suitability of the proposed technology import. In order to streamline and expedite the process for approval of foreign collaboration, the Government has allowed Ministries to approve such collaboration where there is no foreign equity participation, no extension of collaboration, and where the lump-sum and royalty payments are jointly less than Rs.5 million (gross) and the lump-sum is paid in standard instalments.

Technology imports may be assisted by the Technical Development Fund (TDF). This was set up in 1976 to promote technological improvements in existing industrial units by meams of imports of technical know-how, drawings, designs and 'balancing' equipment, and foreign consultancies. No more than Rs.10 million in foreign exchange annually can be approved under the TDF for any unit.

Using their own resources, industrial units are permitted to import drawings and designs to a value of Rs.2.5 million per year, subject to Government approval, though for export-oriented units, such imports are permitted to a value of Rs.2 million without prior approval. Higher amounts are considered in certain cases. There are further concessions for technology imports which are intended to cut energy and other material costs.

Technology embodied in capital goods may be imported, subject only to clearance by the interdepartmental Capital Goods Committee except where there is a formal technical or financial collaboration agreement with a foreign party. Under the 1985-88 import policy many capital goods may be imported without formal approval.

In March 1985, the Government announced a new set of policies for electronics. It includes the liberalisation of industrial licensing and technology imports in the electronics sector, and the permission of foreign equity participation of more than 40 per cent, with special emphasis on manufacturing electronic components and materials, and on other high technologies where India's R&D has been inadequate. Subsequently the Government decided to further liberalise imports of VCR/VCP technology, allowing it to be purchased by individual enterprises instead of centrally.

A new computer policy was announced in November 1984. This covers the manufacture, import and export of computers and computer-based systems and seeks to promote the application of computers for development. It also envisages the setting up of a Software Development Promotion Agency to boost the growth of labour-intensive software equipment for both export and local requirements, including import substitution.

Technology transfer and diffusion

India's national paper for the 1979 UNCSTD[15] included the following measures to promote the transfer and diffusion of new technologies:

(i) strengthening extension service capabilities;

(ii) building up appropriate information systems;

(iii) developing complete hardware/software packages;

(iv) establishing prototype and pilot plant facilities;

(v) fostering engineering design and consultancy service capabilities;

(vi) establishing relevant training programmes for entrepreneurs and managers;

(vii) providing risk capital and fiscal incentives for indigenous technology; and

(viii) creating appropriate institutions for implementing the above measures.

There are already numerous institutions in India capable of fulfilling these goals. For example, the NRDC has had success in carrying the benefits of S&T to rural people and in developing technology appropriate to other developing countries. It has also assisted others to carry out R&D and to file patents and pursue their acceptance, sealing and renewal. In addition it publishes a variety of literature on available technologies, the promotion of invention, and services related to technology development, transfer and diffusion in India. Another important organisation in technology diffusion is the National Productivity Council (NPC), established in 1958 as an autonomous entity under the Ministry of Industry. This seeks to stimulate productivity consciousness, help maximise the use of resources, and thus raise living standards in India. It disseminates information about the concepts and techniques of productivity and management through various media, and organises management seminars and training programmes. It also offers consultancy services, for which there has been growing demand, to help industry, government and service organisations to improve their operational efficiency.

A large number of other government, quasi-government and voluntary organisations have been doing notable work over past decades in the development, transfer and diffusion of appropriate technologies, particularly to rural areas. They include the Khadi and Village Industries Commission (KVIC), the Small Industries Extension and Training Institute (SIET) (Hyderabad), the Council for the Advancement of Rural Technology (CART) (New Delhi), research laboratories under the CSIR/ICAR/ICMR, the Council for Research in Indian System of Medicines (New Delhi), and the ASTRA programme of the Indian Institute of Science (Bangalore).

The biggest success in technology transfer in India has been in agriculture. The agricultural extension system has been promoted jointly by the Central and State Governments, though it operates primarily through the State Agricultural Departments. The sources of know-how of the agricultural extension agencies are the various national and regional research institutes under the Indian Council of Agricultural Research, state universities of agricultural sciences and other regional or local research stations. The research institutes usually carry out field trials of new seed varieties, other agricultural inputs, and improved techniques before attempting to transfer them to farmers by field demonstrations. The new Training and Visit (T&V) System, with a village worker (assisted by supervisory agriculture officers) giving farmers advice on modern techniques and practices, has also been found effective.

In health and family welfare, the extension and delivery system is also primarily managed by State Governments, with some support from Central Government. However, the operation of family welfare bureaux, urban and rural family welfare centres, supply of contraceptives, and education are funded centrally,as are the programmes against blindness, tuberculosis and leprosy. There are also a large number of voluntary organisations in India which promote knowledge about preventive health care, small family norms, etc., as well as rendering actual medicare or family welfare services.

Finally, the State Councils of Science and Technology, which have been set up by nearly all State Governments, have also initiated potentially important programmes in agriculture, health, energy, environmental sanitation and hygiene, and urban/rural development. This has involved both the application of existing technologies and the development of new ones in areas of special relevance.

BANGLADESH

Indigenous technology development

The institutional system for planning and developing indigenous S&T in Bangladesh has three parts. Decisions are made by members of the Presidential Cabinet, either individually or through a Cabinet Committee or collectively at a Cabinet meeting. Policy formulation and planning is carried out by the National Council for Science and Technology and the Science and Technology Division, both headed by the President, assisted by a science adviser. Promotion and execution of the S&T policies, plans and programmes at sectoral levels are entrusted to (i) Government Ministries and Departments; (ii) quasi-government organisations, including universities, research councils, development boards and industrial corporations, and (iii) non-governmental bodies and international organisations. These agencies control and work through a network of R&D institutions and supporting facilities, which are mostly financed by Government.

With regard to the development of trained and skilled manpower for various types of S&T activities and services, the country has several universities, post-graduate institutes, colleges and other training institutions. Informal training facilities are quite extensive and are reported to have created a commendable force of technicians.

For the provision of supporting services, several institutions have been set up, such as the Bangladesh Standards Institution and the National Scientific and Technical Documentation Centre, besides a number of natural resources survey and exploitation institutions.

Technology import

The Department of Industries is entrusted with implementing the Government's investment and technology policies. All foreign private investment requires approval by the Investment Board, which is headed by the Minister of Industry (or his adviser), with the Department of Industries acting as the Board's secretariat. The Department has issued guidelines for foreign investment and technology imports. However, there seem to be no comprehensive mechanisms for the regulation and promotion of technology transfer. Particularly important in this respect is the need to help entrepreneurs to get information on, and access to, alternative sources of technology, to unpackage technologies to be imported, and to negotiate more favourable terms for technology acquisition.

Technology transfer and diffusion

The functions of the proposed National Centre for the Transfer and Development of Technology have already been described (page 18). It would also coordinate the activities of other organisations concerned with technology transfer and attempt to maximise the use of indigenous capacities. In addition, it would collect information on locally available equipment and machinery, technology research and design, engineering capabilities, and industrial infrastructural services. Through holding seminars, industrial clinics, and exhibitions, etc., it would try to popularise technologies already being used successfully and help other institutions to develop the capacity to adapt existing technologies to suit local needs and conditions. Finally, it would liaise with similar centres abroad. Also relevant are the National Centre for Rural Technologies and the non-governmental S&T organs described earlier (page 170). Among the latter, the National Science and Technology Museum displays devices and models to increase public understanding of scientific principles and their practical applications. It also organises science clubs in educational institutions and arrange science exhibitions. Finally, the annual celebration of a National Science Week is being promoted throughout Bangladesh.

SINGAPORE

Indigenous technology development

In 1968, the Government set up the Ministry of Science and Technology with responsibility for devising policy guidelines and programmes for the application of S&T, training of scientific and technical manpower, encouragement of R&D and promotion of awareness of S&T as a tool for economic and social development. In 1973, the Applied Research Corporation was set up as a non-profit-making organisation to work on specific problems and offer consultancy services. A Science Council was established in 1967 to advise the Government and promote S&T.

Technology support services

The Singapore Institute of Standards and Industrial Research provides technical and engineering services to industry. Among its major functions are the provision of testing facilities and determination of standards and specifications for local products. The Department of Scientific Services provides testing and analytical services in a variety of fields; they include chemical and micro-biological quality control and radiation protection, as well as assistance with manufacturing problems.

Manpower training and development

In recognition of the importance of manpower training and development to the successful transfer and development of technology, the Government has given special attention to the supply of technical and specialised personnel. The Manpower Division of the Economic Development Board (EDB) coordinates the development of labour resources, administers the Government industrial training subsidies, supervises training programmes, and facilitates the entry of professional and technical personnel into Singapore.

Under the Joint Company Government Training Scheme, the EDB in conjunction with some established international companies has set up centres to train young apprentices in precision engineering and craft skills. It also coordinates the Overseas Training Scheme and the Industrial Development Scholarship Scheme. The former provides new companies with an opportunity to prepare key personnel for their operations in Singapore, while the latter offers financial assistance to companies providing not less than six months of advanced training in specialist engineering and supervisory skills not available in Singapore. These schemes provide valuable experience and know-how on modern manufacturing practices to technical and managerial personnel.

The National Productivity Board, which aims to raise productivity in all sectors of the economy, organises training courses to upgrade the skills and knowledge of supervisors and managers in management, technology and productivity-related areas.

The University of Singapore provides degree courses in various branches of engineering. Singapore polytechnic and other technical institutions train technicians to meet the growing demands for supervisory staff. In schools also, increasing emphasis is being laid on the learning of science and mathematics to serve as a base for future technical education and training, an emphasis which is also reflected in the vocational institutes which offer courses in a variety of trades. The Industrial Training Board coordinates the training of workers.

TANZANIA

In Tanzania several institutions have been established specifically to facilitate and promote the selection, acquisition, adaptation, development and utilisation of technology (see page 24). Others have been set up primarily for different purposes but nevertheless undertake functions which affect technology. These institutions include the Tanzanian Investment Promotion Committee, Industrial Studies and Development Centre, Investment Bank, National Small Industries Association, and State Trading Corporation. The impact of these institutions has been rather fragmented, however, and in other ways less than satisfactory. In consequence, to ensure that transferred technology is appropriately harnessed and adapted to local conditions, an UNCTAD mission[16] has recommended that the Government should:

(i) lay the foundations for formulating and implementing an integrated national technology policy in the context of the country's overall development strategy;

(ii) designate for this purpose a focal point, such as the S&T Department of the Ministry of Planning, which would have a coordinating role and would be assisted by other institutions;

(iii) register, evaluate, select, acquire, unpackage (where possible) and monitor foreign technologies in an integrated fashion and on an institutional basis;

(iv) assist domestic enterprises find alternative potential suppliers of technology in accordance with the priorities of national development planning;

(v) give higher priority to, and make appropriate arrangements for, technical skill formation and the development of indigenous technological capacity, including R&D; and

(vi) initiate the first steps towards technology planning, starting in key sectors.

Section 4

Overall Assessment

INDIA

Indigenous technology development

India has a strong S&T base with an extensive range of research and training institutions and the third largest pool of S&T manpower in the world. The country's performance in S&T, however, has been mixed. On the one hand, it ranks among the world's leaders in such areas as the development of atomic energy and the use of space technology for communications, natural resource surveys and meteorological forecasts. Its development of agricultural S&T and the performance of its agricultural extension agencies have also been commendable, contributing to a surplus in foodgrains despite considerable population growth. On the other hand, India's performance in the provision of housing, sanitation and drinking water, and in the control of communicable diseases, has not been entirely satisfactory. Equally important, the exploitation of India's huge S&T potential for industrial development appears with few exceptions to have been inadequate and ineffectual. Major constraints include the shortages of trained manpower in engineering which have restricted the commercialisation of research results; the lack of 'venture capital' or of any scheme to insure against risks in transferring domestic technology to industry; and the inadequate linkages between policies for technology development and for technology import.

Technology import

In India, the main problem concerning the acquisition of foreign technology seems to be the multiplicity of channels introduced over the years to permit imports. The duplication is particularly marked for industrial technology, and some rationalisation should be possible.

While the existing guidelines for foreign collaboration lay down certain products where technology imports are not normally permitted, a complete list of priority areas where technology imports are liberalised is still to be compiled. Nor do existing policies take account of the impact of imports on the development and utilisation of indigenous technologies. There are no clear linkages in policy between the two, with the result that the commercialisation of indigenous technology, on which considerable R&D expenditure has already been incurred, is often pre-empted by imports. Better linkages are clearly needed.

Although the major repositories of indigenous industrial technologies in India are in theory involved in Government decisions on technology imports, in practice imports are rarely restricted in order to protect indigenous technology, as it is usually claimed that the latter has not been proven on a commercial scale. This problem is perpetuated by a lack of funds for pilot testing of indigenously developed technologies.

Nor is there any law or other mechanism to involve national R&D institutions with the process of technology imports at the enterprise level, a lacuna which is adversely affecting the absorption and adaptation of imported technologies.

Another weakness is that there are as yet no specific guidelines for assessing technologies in relation to their techno-economic efficiency, energy consumption, employment potential and environmental impact, etc. In their absence, the Technical Evaluation Committee (TEC) of the Ministry of Industry appears to use ad hoc criteria to evaluate technology imports. Its work is made more difficult by the lack of relevant data on comparable technologies. The proposed establishment of a National Register for Foreign Collaboration and a Technology Data Bank, together with the evolution of clear guidelines for technology assessment, should help to improve the situation.

With regard to imported technology absorption and adaptation, the DSIR has evolved a scheme for financial/technical assistance to industry. It is, however, too soon to be able to assess the scheme's efficacy.

In sum, there appears to be considerable scope for refining India's current policies on technology import, to align them with its technology development policy, and to accelerate the inflow of 'appropriate' technologies in defined 'priority' areas.

Technology transfer and diffusion

The Indian strategy for the transfer and diffusion of technology into its economic and social system has been most successful in agriculture. Concerted efforts to diffuse 'rural' technologies, however, have only begun in recent years, and the use of non-conventional sources of energy and of 'intermediate' technologies, as well as the 'blending' of modern technologies with traditional ones, may need to be monitored closely in rural areas.

The responsibility for propagating new methods to prevent, diagnose and control various diseases lies primarily with the State Governments. The overall experience with the existing health-care delivery systems and family welfare programmes, particularly in rural areas and urban slums, has been mixed, with inadequate funding and rather ineffective implementation machinery being major problems. Finally, in the industrial sector, the performance of agencies involved in the development and transfer of domestic technology to small-scale and tiny industries has been fairly satisfactory, although (as discussed above) their efforts at commercialising major industrial technologies have been much less so. There are other mechanisms in India for technology diffusion, such as the National Council for Science and Technology Communication, but most are too new for their success to be judged.

BANGLADESH

The evolution of S&T policies and of the implementing infrastructure is still in its initial stages in Bangladesh. Proper mechanisms to regulate technology imports, and to facilitate choice, unpackaging, absorption and adaptation of such technologies are yet to be evolved. Meanwhile, existing institutions for the development of indigenous technology appear more academic than business-oriented. They also seem to lack the organisation, manpower, and financial and fiscal facilities, needed to develop S&T effectively and to apply it to the country's socio-economic development. However, recently initiated technology transfer and diffusion programmes hold out considerable promise of improvements in this respect.

SINGAPORE

It is difficult not to conclude that Singapore's socio-economic and technological development policies have been highly successful. Not only do their goals appear to have been well designed, in keeping with the requirements of a small territory lacking in natural resources, but their implementation has been relatively effective, and no doubt this contributed to the creditable economic performance of the country. Its economy is now focused on technology-intensive and high value-added industries, which in general are competitive internationally. If the resources vested in the various foreign companies operating in Singapore are excluded from the assessment, however, the country's indigenous technology base appears much less strong, especially in industry. All the same, it is indisputable that Singapore has transformed itself from an economy based essentially on services and trading, into one which is both diversified and prosperous, despite the recent slowdown in growth.

TANZANIA

It can be seen from the earlier discussion that technology policy in Tanzania is still at an early stage of evolution. But existing institutional mechanisms do not seem to have been very effective either for selecting and adapting imported technology or for developing indigenous technology. Various measures have been suggested (e.g. by the UNCTAD mission cited earlier) to enhance the effectiveness of its technology policy and related institutional machinery in order to realise the country's long-term goal of technological self-reliance.

Part II

TECHNOLOGY POLICIES AND ECONOMIC AND SOCIAL DEVELOPMENT : PLANNING FUTURE IMPROVEMENTS

Section 1

Introduction

This part of the report attempts to provide a conceptual policy framework at macro- and micro-levels to promote and facilitate technological change and suggests associated structural adjustments, both nationally and internationally. Before proceeding, however, it may be useful to make certain preliminary remarks about the concept of technological change and the impact of technology on society.

New technologies emerge through the process either of 'technology-push' (the supply of technology) or of 'market-pull' (demand). In analysing the mechanics of technological change and devising appropriate promotional policies, several parties and criteria need to be considered. These include the technology supplier, the recipient or client, and in the case of 'technology-push' categories of change, the technology change 'agent' (or 'extension agency') whose function is promotional. In societies or organisations with low levels of literacy and technological orientation, or traditions and cultures resistant to the introduction of new techniques, the change agent's task is extremely important. It may involve setting up demonstrations to convince potential clients of the benefits of new technology, and identifying and removing obstacles to change.

It is now well-understood that technology interacts with society in various ways. They include its impact on: the environment and ecology; income distribution; employment (quantity, pattern, duration, nature, occupational health and safety); public security; consumption patterns; cultural values; and training. All these aspects need to be taken into account in formulating any policy to manage technological change,to maximise its benefits and minimise its costs.

We can now discuss the nature of the policy issues involved in the management of technological change, and suggest specific policy measures for ensuring its successful management by countries at different stages of development.

Section 2

Policy Issues

The promotion of technological change raises many policy issues. They include the need to decide whether technological change should be promoted primarily through imports or more by developing and utilising indigenous technologies, resources and manpower; the nature of technologies/goods to be imported or developed and utilised indigenously; the criteria for assessing and selecting technologies; the R&D priorities for indigenous technologies; the associated requirements of technology development, support and manpower training; the fiscal and monetary policies for promoting technology imports, and indigenous technology development and utilisation; and the means to transfer and diffuse technologies within the country. We restrict our discussion to some of the more important of these issues.

As far as technology imports are concerned, various policy measures can be adopted by governments. They include the enactment of suitable patent laws to protect the industrial property rights of the foreign technology suppliers in the host countries; the conclusion of double taxation agreements; and the implementation of corporate taxation and other fiscal policies to attract the foreign suppliers of technology.

But the choice between imported and indigenous technologies is not exclusive. As the Government of India's Technology Policy Statement (January 1983) puts it, "technological self-reliance" does not imply "technological self-sufficiency". Even the most advanced countries engage in a two-way flow of technology. On the other hand, continued dependence on foreign technology and other inputs, especially in strategic sectors, can endanger a country's economic and even its political independence. By reducing the demand for indigenous technologies, it tends to sap indigenous initiative and perpetuate the 'vicious circle' of technological dependence or 'technological colonialism'. This, in turn, further weakens local production and S&T capabilities. Inadequate assessment mechanisms lead to the import of inappropriate technologies, while indiscriminate imports may not suit the cultural and social preferences of the majority of people in the importing country.

In this situation, countries in the initial stages of development need to begin by developing indigenous capabilities in basic needs' sectors such as food, energy and transport, and other strategic sectors like defence. Imports of know-how, equipment or materials even for these sectors should not be excluded automatically, but the indigenous availability of relevant capabilities or inputs, and the possibility of developing them,should be considered first. Once strategic sectors have been indigenised, countries should select other sectors where domestic technological capabilities are reasonably strong or could be built up quickly, with a view to increasing employment and promoting import substitution. As countries begin to fulfil the basic needs of their people, they should attempt to develop or acquire technologies that raise productivity and international competitiveness. This may require importing technologies, but in doing so, care is needed to avoid weakening domestic R&D capabilities or markets. This necessitates careful management of tariffs, subsidies, and other fiscal policies for promoting domestic R&D capabilities to produce indigenous technologies or products which are internationally competitive. Likewise, where technology imports are banned, special measures are needed to develop indigenous R&D capabilities.

Another important area is the process of technology diffusion. Although this differs from one country or sector to another, there are some essential requisites common to most cases:

(i) training personnel in the use of new technologies;

(ii) training extension educators or other 'change agents', who often have to intervene between the suppliers and recipients of know-how, particularly in agriculture and health but also, in many cases, in industry and services;

(iii) organising inputs (including machinery, equipment, raw materials, finance, infrastructure) required to operate new technologies;

(iv) adapting and absorbing technologies transplanted to new social/economic/geographical/agricultural/political environments;

(v) organising effective 'feed-back' systems from the ultimate beneficiaries and recipients of new technology, to extension agencies and suppliers;

(vi) developing a cadre of research staff competent to make use of such 'feed-back' and to improve existing products and technologies; and

(vii) enacting special measures to assist those adversely affected by technological change, in order to overcome their resistance to such change.

Adaptation of technology to new situations throws up a variety of problems. Adapting to a new social environment may be necessary to ensure that the end-products suit the preferences of the new group of consumers; adapting to changes in economic factors may involve, say, the use of less mechanised techniques where capital has become scarcer and labour more abundant; adaptation to a new geographical climate may require 'tropicalisation' of designs and/or equipment; promotion of new products in a different cultural environment may involve influencing people's consumption habits or mental attitudes; and adaptation to a new political environment may involve various changes in technology.

Absorption of technology in a country or organisation depends not only on the technological abilities of the recipient but also on its social and economic policies and legal framework. For instance, if a country bans the renewal of foreign collaboration agreements, industrial enterprises will need to take steps to absorb the foreign technology within the period of the agreements.

Resistance to the changes which would result from introducing new technologies is, perhaps, central to the successful management of technological change. The major causes of such resistance include: economic factors (e.g. the effect of new technology on the distribution of income and wealth); social factors (e.g. personal inconvenience and feelings of insecurity; violation of established norms; absence of prior consultation or debate; concern over changes in the structure of society; adverse impact on health and safety); and environmental factors.

Resistance to change is primarily a 'human' problem and not a 'technical', 'financial' or 'legal' one. If handled sympathetically, it may be reduced if not totally eliminated. For instance, it seems that change (whether technological or otherwise) is usually more acceptable: when all its implications are understood; when it does not seem to threaten security; when those affected have helped to create it rather than having it imposed upon them; when it is preceded by consultation or education; when it is implemented after any previous changes have been successfully assimilated; when those affected can see the gains; when it results from accepted policies or principles, rather than from diktats or fiats; and when its outcome is reasonably certain. Within organisations, change is usually more acceptable if the staff have been trained to plan for improvements rather than accustomed to static procedures. Lastly, change is more acceptable to people new to a job than to those well established.

Appropriate policies therefore include general extension education; better communication with the people affected, including their involvement in the decision-making and/or implementation processes; and adjusting the pace of technological change.

Section 3

Technology Policies

Here we consider policies relating to technology assessment and choice, the development and promotion of indigenous technology, and the transfer and diffusion of technology. Policies concerned with monetary and fiscal incentives, manpower requirements, environmental controls and legal instruments are discussed in subsequent sections.

Technology assessment and choice

Technology assessment (TA) is needed because project appraisal systems in most countries are usually confined to economic cost-benefit analyses, which focus on profitability, foreign exchange balance and other financial considerations. Social costs and benefits, such as the impact on employment, income distribution, working conditions, environment and so on, are generally ignored. It is because many new technologies have been observed to affect these areas adversely, that there is now growing support for TA - to take account of such impacts when making decisions about the choice of technology. While TA is designed to lead to a more appropriate choice of technologies in relation to socio-economic and other national goals, it is important to ensure that 'technology assessment' does not become 'technology arrestment' through undue concentration on the possible adverse effects of new technologies without consideration of possible solutions.

The United Nations Environment Programme (UNEP)[17] has suggested the following general criteria for TA: satisfaction of basic human needs; promotion of the concept of self-reliance through the use of domestic human and natural resources; and environmental soundness. Additional criteria could include: maximising employment and/or production per unit of investment; maximising energy efficiency or increasing the use of alternative, renewable energy sources; maximising use of indigenous raw materials, manpower and other resources; and simplicity of operation or maintenance of machinery or products. The choice of criteria, and the weights assigned to them, may vary from sector to sector as well as between countries. A distinction should also be drawn between TA conducted in the public and private sectors[18]. In the public sector, three elements are essential for successful TA: the assessment must be conducted in a flexible structure, by inter-disciplinary teams, with provision for public discussion of the results. In the private sector, a decentralised approach may be more appropriate, with individual industries conducting TA of the products and processes they have developed. As regards the institutionalisation of TA, the United States National Academy of Sciences has made the following recommendations[19]:

(i) the agency must be insulated from direct policy-making powers and responsibilities, lest it acquires a vested interest either in promoting particular technologies or in maintaining the status quo;

(ii) the agency must not be given the authority to screen or clear new technologies itself, so as not to give it a veto power over all other agencies or authorities of Government;

(iii) the agency should have the power to study new technologies and make recommendations to the appropriate authorities, being so located organisationally that its recommendations are influential, but it should not act either in support of or against any innovation; and

(iv) the agency must make a special effort to hear diverse viewpoints, particularly of citizens' groups and private associations, as well as business and government organisations.

In conclusion, there are strong arguments for all countries to undertake TA. This is especially so for newly industrialising and other developing countries, whose societies are experiencing rapid technological transformation. TA should be institutionalise with a view to improving the choice of technologies, investment policies, and research priorities. It should cover both imported and domestically developed technologies.

Development and promotion of indigenous technology

As discussed earlier, the aims and objectives of a country' technology policy should be derived from its socio-economic, security and other national goals. The policy itself should cover technology imports, development, diffusion and utilisation. It could be in the form of a Science and Technology Plan, specifying, inter alia, the priorities, programmes and projects for investments in S&T activities. Such plans are now being prepared in developing countries like India and in the centrally-planned economies as an integral part of the state's socio-economic plans. Implementing the S&T plans is carried out by research laboratories, academic institutions, in-house industrial R&D establishments and various technical service or support institutions - in some cases new institutions may have to be set up to complement existing ones.

We now turn to the issue of research priorities and of associated policy-linkages, and the types of S&T institutions needed.

Research priorities

It has been suggested[20] that in determining its research priorities a country should delineate the areas in which: indigenous technologies are to be the basis of productive activities; traditional technologies must be preserved and developed; and capabilities for choosing, modifying and absorbing the imported technologies must be built up. A country seeking self-reliance should start with critical and vulnerable sectors. For instance the Government of India's Technology Policy Statement envisages the fullest support in the development of indigenous technology to achieve technological self-reliance and reduce dependence on foreign inputs in such areas as defence, agriculture, and energy. The next areas of priority include those sectors which, potentially at least, would add substantial value to a country's natural resources or to its imported raw materials or other goods. These are very broad criteria and within each sector they would need to be further refined in consonance with overall socio-economic priorities.

The guidelines[21] adopted by the Government of India in the mid-1970s for its sponsored scientific research may serve as a model for other countries. These directed research to:

(i) create or develop any new source of energy capable of being commercially exploited and improve efficiency of any existing method of energy generation/distribution, and create or develop any new source of proteinous and/or other nutritious food for human consumption;

(ii) conserve energy, food or any other scarce material resource by devising new or improving existing methods of processing/manufacture;

(iii) devise better techniques for utilising or re-cycling wastes;

(iv) develop better techniques for controlling or reducing pollution;

(v) develop improved basic drugs/medicines for treating more commonly prevalent human/animal diseases;

(vi) develop improved techniques of family planning, likely to find wide acceptance;

(vii) develop improved techniques of construction (including new building materials) to reduce costs substitute common for scarce materials, especially in rural areas;

(viii) develop improved plant nutrients and plant protection chemicals to raise agricultural yields;

(ix) devise new production techniques which conserve foreign exchange; and

(x) achieve such other prescribed national social, economic and industrial objectives.

It would seem useful for other countries, especially developing ones, to formulate their own research priorities in this way, in keeping with their own national goals and bearing in mind the limited resources available for investment in R&D.

Policy linkages

Once priorities for indigenous technological development have been identified and decisions taken on investment in supporting relevant R&D, it is necessary to ensure their consistency with a country's

(i) regulatory policies, if any, governing the establishment of economic activities based on indigenous know-how;

(ii) long-term technology import policies, to ensure that future imports do not pre-empt the utilisation of indigenous technologies; and

(iii) policies relating to resource allocation for production, due priority being given to setting up production-units based on indigenous technology.

As the experience of India and, perhaps, of other countries shows, lack of coordination of such policies leads to unnecessary waste of resources invested in indigenous technological development.

Technology development institutions

As an instrument of policy, institution-building is relatively recent, and in many developing countries, S&T institutions have come into existence piece-meal, mainly as a result of sectoral initiatives. In a few countries, however, including India and Singapore, a cohesive network of S&T institutions has been established through government policies to promote specified goals. Such institutions include those devoted to R&D, technical services/support, natural resources surveys, technology transfer, and manpower development. Their establishment, and the linkages between them, should be related to a country's economic and social development goals. Institutions whose objectives are mutually contradictory or in conflict with major national goals or policies should obviously be avoided. Their links with industry and other users, academic/training institutions, and concerned Government departments also need to be promoted.

Technology development institutions can be broadly classified as follows:

(i) government/quasi-government R&D laboratories set up on a discipline-oriented basis;

(ii) cooperative research associations;

(iii) private research foundations and trusts which undertake independent contract research;

(iv) in-house R&D units in industry;

(v) institutes or colleges of engineering and technology or technical departments in universities, undertaking contract research or consultancy work; and

(vi) institutions upscaling laboratory know-how into commercial activity. In most cases, such activities are undertaken by industrial units themselves, with or without support from other R&D or technology transfer institutions.

It is difficult to commend any technology development institution as a model for all countries or situations. However, experience in the industrial countries, and many developing countries, seems to suggest that industrial R&D is best performed in close proximity to production lines or through industrial cooperative research associations. A competitive environment to promote technological innovation, governmental support, provision of needed finance, equipment and manpower are other preconditions of successful technological development. Government or quasi-government research laboratories and other institutions engaged in developing industrial technologies seem to be most effective, and of greatest social relevance, when they function on the basis of a 'customer-contractor' relationship.

Technical service and support institutions

Technical service and support institutions form a crucial link in the generation of domestic technology as well as in making the best choice and use of imported technology. While some of these institutions provide the required data base/information and other facilities needed to plan and perform R&D activities, others help in commercialising the results of such activities. The functions performed by these institutions fall broadly into the following categories:

(i) collecting and disseminating technological information (undertaken by national registries, technology data banks, information and documentation centres, and specialised S&T libraries, etc.);

(ii) surveying and mapping natural resources;

(iii) standardisation, testing and quality control;

(iv) electronic data processing (undertaken by centralised computer facilities);

(v) selecting appropriate technologies, equipment and materials; designing and engineering production plants; preparing feasibility and project reports; undertaking management and training; and providing economic/financial consultancy services.

While the functions performed by these institutions are essential to technological development, the role of design-engineering-consultancy organisations in translating the results of lab-scale research into commercial activity may be one of the most crucial. Likewise, these institutions' rich experience of technology transfer is specially valuable in helping them to undertake their role in technology assessment and choice, both of domestic and imported technology.

Technology transfer and diffusion

By translating or carrying research results from laboratories and other R&D institutions to industrialists, farmers and others, technology transfer institutions (e.g. national research and development corporations and agricultural extension agencies) play an important role in the process of technological change. Also important are those institutions devoted primarily to the popularisation of science and technology, such as the National Council for Science and Technology Communication (NCSTC) in India, science and technology museums, and academies or associations of scientists and technologists.

A resolution on technology transfer adopted at UNCTAD IV recommended[22] that each developing country should ensure "the establishment of appropriate institutional machinery, including a national centre for the development and transfer of technology, with urgent attention being paid to defining the role and functions of such a centre, including the principal linkages which need to be established with other national bodies or institutions". The UNCTAD <u>Handbook on the Acquisition of Technology by Developing Countries</u>[23] suggests that national centres for the development and transfer of technology should: assist, within the framework of national social, economic and political constraints, in the identification of technological needs for a variety of economic activities; assist in the acquisition and analysis of information required on alternative sources of technology from all available sources, domestic and foreign, and in its delivery to users; assist in the evaluation and selection of technologies appropriate for different jobs, with an emphasis on decision-making; assist in unpackaging imported technology, including assessing its suitability, direct and indirect costs, and the conditions attached; assist in negotiating the best terms and conditions for imported technology, including arrangements for registering, evaluating and approving agreements for its transfer; promote and assist the absorption and adaptation of foreign technology and generation of indigenous technology, linked specifically to design/engineering, research and development; promote the diffusion of technology already assimilated, whether indigenous or foreign; and coordinate policies and evaluate their internal consistency in relation to the transfer and development of technology.

These national centres should have a double impact: at the macro-level on the formulation of technology policies and a technology plan, and at the micro-level on the productive system and enterprises themselves, both public and private. According to the UNCTAD Secretariat,[24] the centres need to be linked with other institutions and agencies such as: the planning organisation responsible for formulating the development strategy and drawing up the development plan or programme; the authorities responsible for approving foreign investment and for devising and administering investment laws, regulations and fiscal or other incentives; the organs responsible for project preparation and/or appraisal; the education and training system, for both planners and skilled manpower; the organs responsible for industrial property, standardisation and quality control; the R&D institutions (which are too frequently isolated from both imported technology and the productive system). It is, however, recognised that such structures may be difficult to establish and implement effectively in free-market economies where governments exercise little control over technology acquisition by individual enterprises and the development and transfer of technology within the country.

Within industries, technology transfer and diffusion can be promoted in a variety of ways which encourage backward and forward linkages with other industrial units. They are greatly facilitated by encouraging the mobility of S&T personnel, not only from one place of work to another (e.g. by encouraging scientists to hold lecture tours), but also by institutionalising staff exchanges between sectors like education, industry and research. Organisations like National Productivity Councils or Boards, as in India and Singapore, are also crucial, by making industries, organisations and individuals more conscious of the role of improved technologies and management techniques and providing the necessary training and consultancy services.

While there are many institutional mechanisms for the transfer and diffusion of technology in the industrial sector, that into rural areas requires different types of institution. In agriculture, the example of India's extension system could perhaps be commended to most other developing countries. In health, education and extension agencies, the 'bare-foot' Chinese doctors or the Indian community health volunteers seem to play crucial roles. In the promotion of cottage and small-scale industries in the rural areas, institutions like the Indian District Industries Centres, CSIR's Polytechnology clinics, and the State S&T Councils are potentially important. In the industrial countries, movements of the "Do It Yourself" (D.I.Y.) type are important in making people technology-minded and encouraging them to perform routine maintenance, repairs and simple technological tasks themselves.

Conclusions

In sum, the broad conclusions of this Section are that:

(i) all countries should take steps to devise proper systems for technology assessment and choice suited to their own requirements, and to institutionalise the TA process in government as well as in industry. Such systems should cover both imported and domestically developed technologies and should be related to the country's value systems, research priorities and investment policies;

(ii) the delineation of research priorities in the light of the socio-economic, security and other goals of a country should be given more consideration and emphasis than in the past;

(iii) policies to develop indigenous technology should be effectively linked with policies to set up production or other economic activities based on such know-how, to policies on technology imports, and to policies on investment;

(iv) contract research should form a major part of the activities of technology development institutions so as to orient these institutions to the needs of industry and the community;

(v) industrial pilot plants, prototype development facilities or other mechanisms for scaling-up laboratory results to the commercial level should be encouraged with assistance from appropriate design-engineering firms and government; and

(vi) extension services, productivity movements and other mechanisms for the internal transfer and diffusion of technology should be encouraged, as should the mobility of S&T personnel, in order to promote and facilitate technological change.

Section 4

Economic Policies

Economic policies (i.e. financial and fiscal policies) can play a crucial role in technological change through promoting R&D (in general or in particular), influencing the pace, magnitude and direction of change (especially in industry), and promoting new products or processes which satisfy specified social or economic criteria. These aspects are discussed in detail below.

Promoting R&D

Fiscal policies are widely used to promote investment in R&D, and to channel it into priority areas. In India, for example, under the Income Tax Act, all expenditure incurred by an assessee on scientific research can be deducted from tax liability. Likewise, any sum paid to an 'approved' scientific research association, university, college or other institution for undertaking such research can be deducted. Before April 1984, Indian income tax law had also provided for the weighted deduction of expenditure incurred by assessees on approved programmes of scientific research in priority areas, which were executed either in approved scientific research institutions or in recognised industrial R&D units. Subsequently, however, the provision was withdrawn and Indian fiscal incentives no longer distinguish between scientific research in priority areas and that in other areas. Apart from direct tax concessions, the Government exempts from customs duties all imports of instruments and equipment needed by those scientific research institutions which have not been established for purposes of profit.

A study of S&T policy instruments in 10 countries (including South Korea, India and several in Latin America)[25] found that fiscal incentives did not appear to have been very effective in inducing industrial firms to undertake S&T activities. In fact, tax incentives seem to have certain disadvantages compared with financial policies[26]. They bring unintended windfalls by rewarding people for doing things they would have done anyway; they result in undesirable inequities; they can lead to higher tax rates; and they can undermine budgetary control and public accountability. On the other hand, fiscal policies also have some advantages. Thus, compared with assistance through grants or subsidies, tax incentives interfere less in the marketplace and allow more private decision-makers to retain their autonomy; they require less bureaucracy and avoid the need to make difficult distinctions or to set arbitrary requirements for the receipt of assistance, and consequently receive a more favourable reaction from industry; they are more permanent and stable, in that they do not require annual budgetary review; and they have a high degree of political feasibility. While it is not the purpose of this Report to assess in detail arguments of the relative costs and merits of fiscal and financial policies as means of promoting innovation and R&D, it does appear that fiscal policy, if properly designed and implemented, can be a major instrument to promote and direct investment in R&D.

There are many different financial policies for supporting R&D. They include: full or partial grants by government (as in India, Japan, Italy, Singapore, South Korea, Argentina and Brazil); special funds for technological development and support activities (as in Japan, Italy, South Korea, Peru and Brazil); special credit lines by financial institutions (as in Argentina and, more recently, India); and compulsory levies on industry (as in Peru, South Korea and India).

Industrial R&D involves a complex range of activities, and until a commercial plant has been operating successfully for a period, neither industrial entrepreneurs nor financial institutions will have enough confidence to invest in or lend to an enterprise using new technology. As a result, in India, for example, almost 90 per cent of R&D finance come from the Government in the form of 'grants', with comparatively meagre returns in commercial terms. The situation is similar in other developing countries.

The expenditure required for lab-scale research, pilot plant operation/prototype development, and commercial activities, typically increases in the ratio of 1:3:10. While sufficient funds are provided in many countries for lab-scale work, the translation of the results of such research into pilot plant operation/prototype development, and commercial scale activity, is poor. Several reasons can be adduced, viz. the inadequate 'venture capital' needed to launch new technologies; an absence of schemes to underwrite possible losses or insure prospective entrepreneurs against risks; and weaknesses of indigenous design-engineering capabilities for translating the results of lab-scale work into commercial production. Analyses of the experience of industrial R&D financing policies and assessments of their efficacy show that conversion of lab-scale research into commercial activity is most effective in countries like Japan and the United States where adequate 'venture capital' is available to entrepreneurs for experimental development of commercial-level activity based on new technologies, and/or where State and other financial agencies insure the prospective entrepreneurs, fully or partially, against the possible losses or risks involved. Unless one or other of these two conditions is satisfied, the translation of the results of indigenous R&D into commercial-level activity generally remains rather poor. Finance houses fund such activity, but experience in Argentina and elsewhere has shown that the special credit lines are unlikely to prove effective unless they are underwritten or covered by loss-insurance schemes.

Influencing the pace, magnitude and direction of technological change

In addition to promoting R&D, institutional funds and bank credits can be a powerful instrument in promoting the demand for technologies, both for local and export markets, as well as in priority areas. By introducing technology-related criteria into the policies and procedures for evaluating loan applications, it is possible to use such credits as levers, influencing the pace, magnitude and direction of industries' technological behaviour. The purchasing power of the State can also be used as a powerful tool in this way.

With regard to fiscal policies, accelerated depreciation or investment allowances on new machinery or equipment based on the use of technologies which satisfy specified criteria can be used to augment production using such technologies. Indirect levies, such as customs duties and excise and sales taxes, can likewise influence the choice and use of technology.

Promoting new products or processes

In addition, fiscal and financial policies can be used to promote new products and processes which satisfy certain socio-economic criteria. For instance, to advance its socio-economic goals, a country may find it desirable to promote the introduction of, say, machinery and equipment which is more fuel-efficient or uses new sources of energy (e.g. solar), or the substitution of scarce materials, or the installation of pollution control mechanisms. Various policy instruments could be used. For example, the government could purchase equity in new industries based on the desired technology. Alternatively it could make grants or subsidies or concessional loans through its financial institutions. Appropriate fiscal policies could include direct tax exemptions for a limited period for industries fulfilling specified criteria, reduced excise duties or other indirect taxes on their manufactures; and, where relevant, reduced price controls. Such instruments are now being widely used in India and other countries to influence the direction of technological change and promote the use of products and processes which save scarce resources, to encourage the substitution of non-renewable by renewable resources, and to promote the fulfilment of many other socio-economic objectives.

Section 5

Social Policies

This section discusses various aspects of social policy, in particular those relating to the development of human resources to meet the needs of technological change. The availability of qualified, scientific, technical and managerial personnel, and the nature of their skills, are a primary constraint on technological development. Personnel may be needed at all levels of skill, from the lowest but key level of technician or operator through the middle level of supervisor and executive to the highest level of scientist, technologist, manager and entrepreneur. To promote technological change therefore, any educational system needs to cover disciplines not only in various areas of S&T but also in important related areas such as business administration, management, economics, accountancy and extension. In primary and secondary education, elementary scientific knowledge should be taught as a foundation on which higher technical, managerial and other skills are built. These elements need to be incorporated into a long-term forward-looking education plan, to take account of the long gestation of changes in the educational system, as in the technology development process. Many years may pass from the recognition of the need for personnel with certain skills to the creation of new institutions, the recruitment and training of teachers, and the emergence of their first batch of students.

In economic terms, education and training is investment in skill formation. Human resource development, however, is a much wider concept, which includes helping people to identify their particular aptitudes; encouraging and motivating them to develop these aptitudes; providing opportunities and facilities for their education and training, including informal education and retraining; and placing trained or educated persons in positions where their new knowledge and skills can make the best contribution to national social and economic development. Discovering persons who have, or who can be helped to develop, an aptitude towards science and technology, entrepreneurship, business management, accountancy, etc. should be a special task in education planning and manpower development.

The accelerated rate of technological progress will increase demands on all countries' educational systems. Inasmuch as fast changing technologies require workers and managers continually to upgrade their skills or acquire new ones, the curricula of technical education, training and management institutions need to be continuously updated. In addition, more facilities are required to provide continuing education and reorientation or retraining for people already in work. These can be provided through existing educational institutions and training facilities in factories, or through new forms of institution devoted specially to providing continuing education and retraining. In any case, it is clear that the concept of education as a formal medium-term process will have to give way to the concept of education as a lifelong process, especially in technical trades, managerial or technical skills, and even skills in social communications.

Changes in the curricula of educational and training institutions will require the reorientation or retraining of teachers or the induction of visiting lecturers to fill gaps. These tasks can be facilitated by strengthening linkages between the educational, industrial and research systems, and encouraging the mobility of personnel among them; by establishing a mechanism to review curricula; and by adopting a policy to provide sufficient funding to programmes of direct relevance to national development plans and goals. Further, to improve the effectiveness of science and technology, students' training in universities, colleges, vocational and other institutions, and the relevance of their courses to the needs of society, it may be desirable to link class-room instructions with work-experience through 'sandwich' type programmes, or require students to attend 'practice schools' in factories, or work on projects of industrial /social relevance as a precondition of obtaining a degree or diploma. Apprentice industrial training schemes are also relevant in this context.

Subjects which need to be introduced in the curricula of engineering colleges, technology institutes and other high-level educational institutions include technology forecasting and technology assessment, entrepreneurship and managerial skills. The last of these is particularly important as it is efficient management which, primarily, leads to the successful deployment of technological and other resources. All countries, and especially the developing ones, need to increase their facilities for training competent managers, by setting up more management institutes or management faculties in universities and colleges. The development of entrepreneurial leadership and associated skills is also essential, as it is the entrepreneur who catalyses the factors of production and is at the heart of development in almost all societies. Entrepreneurs obtain satisfaction by starting projects, breaking new ground, and experimenting with what may appear to be risky if rewarding propositions. Experience in several developing and developed countries has shown that through a carefully designed training programme, people can be helped to develop and improve their basic entrepreneurial traits and thus their chances of success in starting and managing new enterprises. This has been the experience of the Small Industries Extension and Training Institute (SIET) at Hyderabad in India and of the Institute for Small-scale Industry at Manila in the Philippines; other countries can provide similar examples.

In conclusion, it appears that to have the maximum impact on the promotion of technological change, any policy framework should have the following characteristics:

(i) the concept of perspective planning in education and training for technological development in order to ensure that the educational system can train people with relevant skills in a context of changing technologies;

(ii) the closer interaction between education, industry and research systems to help technical, vocational and other institutions to reorient and revise their curricula on a continuing basis in conformity with the needs of industry and society;

(iii) the increased mobility of personnel among the education, industry and research systems so as to give a more practical bias to programmes in schools, colleges and universities and to improve teachers' understanding of industry- and research-based problems;

(iv) the introduction of 'sandwich' type courses by engineering and management institutes and the adoption of other mechanisms to provide students with 'on-the-job' experience in industry or other working environments. This would greatly increase students' appreciation of practical problems and make them better suited for industry and other sectors;

(v) the provision of strengthened facilities for continuing education and retraining of workers and managers in order to re-orient, improve and add to their skills for meeting the increasing demands of technological change; and

(vi) the increase in emphasis on developing managerial, entrepreneurial and associated skills such as accountancy and S&T communication.

Section 6

Environmental Policies

This section considers policies relating to technological change in the context of ecological conservation and environmental protection. All major developmental activities are almost inevitably associated with some negative environmental impacts. Environmental impact assessment (EIA) enables decision-makers to take account of the possible effects of investments on environmental quality and provides a tool for collecting and assembling the data which planners need to make development projects more environmentally sound. EIA is increasingly being applied to identify policies which achieve economic development through a more rational and sustainable use of resources.

There are two basic environmental considerations which are receiving increasing attention world-wide. One is the control of pollution, whether of land, air and water or by noise, heat and light. The other is the conservation of natural resources, particularly the non-renewable ones which will be enhausted in measurable time if their consumption continues to increase at recent rates. Past lack of attention to these matters has been responsible for environmental degradation which - unless necessary precautionary and remedial steps are now taken - could reach a point of no return, even threatening human survival itself.

Pollution control

In many countries legislation has been enacted requiring industrial enterprises (considered to be a major cause of pollution) to take necessary preventive or remedial measures to ensure that their effluents and atmospheric emissions are free (or contain less than the prescribed concentrations) of the more harmful elements and that these are discharged into the land, water, or atmosphere in a particular way. Many countries levy a tax on the volume of water consumed by water polluting industrial enterprises. The proceeds fund not only the monitoring of water and other pollution in specified locations, but also the provision of necessary supporting and administrative facilities. In the United States, for example, the Environment Protection Agency (EPA) fixes standards of purity for industrial effluents and emissions. Over the years these have become more stringent on the basis of the best standards already achieved in particular industrial sectors, and enterprises not conforming to the requisite minimum standards are penalised. In many developing countries also, legislation has been enacted allowing fines to be imposed on enterprises which fail to conform to industrial effluent and emission standards. Some countries, particularly those where legislation has been introduced only recently, promote the installation of pollution control and monitoring equipment by providing subsidies and other forms of assistance. The development of pollution control technology has been given high priority in several countries.

But it is not only industrial undertakings which cause environmental pollution. Mining and electricity generation also contribute significantly, as do municipal bodies and many larger non-industrial undertakings. Many countries now require empty pits or hollows resulting from opencast or underground mining to be filled to reduce the danger of landslides and floods. Depending on the availability of water and financial resources, municipal bodies in developing countries are increasingly attempting to construct urban drainage and sewage systems and undertake treatment of sewage before it is discharged into wastelands or water. Increasing use is also being made of urban sewage and other solid wastes as sources of organic manure. Automobiles are another major pollution source, particularly in the large urban centres of developed and developing countries. A number of countries have set compulsory standards on the emission of lead, carbon-monoxide, smoke, etc. from automotive vehicles. Likewise, many have specified standards of noise-emission from vehicles and from industrial and other machinery and equipment. Finally, increasing attention is being paid to pollution from household sources, with efforts in some developing countries to improve the quality of household fuels and to propagate the use of smokeless stoves and other non-polluting cooking devices.

In all countries where pollution control legislation has been enacted, a network of statutory, promotional and regulatory institutions has been set up to administer pollution controls. The United Kingdom, Canada, Germany (FR) and many other developed countries have such a network. Some developing countries, too, have taken steps in this direction. For instance, in India, almost all the States and Union Territories have their own water and air pollution control boards, with statutory powers to administer the relevant legislation. Separate departments of environment and ecology have been created in a majority of the States in India while an independent department of the environment has existed in New Delhi since November 1980. Central legislation to prevent and control water and air pollution was enacted in India in 1974 and 1981, respectively. However, much work remains to ensure the effective implementation and enforcement of these acts. Analytical R&D work relating to the monitoring and control of pollution is undertaken in several developing as well as developed countries (e.g. by the National Environmental Engineering Research Institute (NEERI) at Nagpur in India), while in an increasing number of developing countries pollution controls and other environmental considerations now form a part of industrial licensing and related policies.

The introduction of pollution-control legislation and related administrative machinery should be considered by all countries. Without them, there is a risk that the environment for technological development will not be sustainable in the long-term.

Natural resource conservation

It is now widely recognised that most natural resources are depletable and that in a few cases resources could be exhausted within a matter of decades. Even the exploitation of seemingly renewable resources, like forests, has been a cause of concern, particularly in countries which have not enforced laws on conservation and development. In India, for example, the forestry policy introduced in 1952 envisaged that a third of the land should be under forest. However, difficulties in implementing this policy effectively and the increasing demands of agriculture, irrigation, industries and human settlements have resulted in the forest cover being reduced to 11-12 per cent. While the use of a country's forest and other renewable resources in supplying goods and services is desirable, it is essential to ensure the long-term ecological security of a country (and of the world as a whole), by the adoption of suitable restorative, recycling and conservation policies.

It is now generally realised that the 'throw-away' culture of many post-industrial societies poses a serious threat to the conservation of exhaustible natural resources like oil and other minerals. Increasing attention is therefore being paid, especially in industrial countries, to recycling and using 'wastes' (defined as resources not utilised). In a wider sense, even water flowing down a gorge is 'waste', unless it is used to generate hydroelectricity, for irrigation, or for other purposes.

Likewise, a large part of the sun's energy is also being 'wasted', and it is only in recent years that its exploitation through photovoltaic, biomass and other techniques has been systematically undertaken and improved. More pertinent in the context of conservation policies, however,is the need for legislation (as in Germany (FR), Japan and a few other countries) under which industrial and other enterprises are required to treat or recycle certain industrial effluents or other wastes and byproducts in order to re-use the valuable components they contain. Some metals, such as iron and copper, have been widely recycled, but others (including aluminium) have not. All societies, whether industrialised or not, need to develop a 'recycling culture' consciousness, so as not only to convert 'wastes' into 'wealth' but also to prolong the availability of non-renewable resources. Increasing substitution of non-renewable by renewable resources is another strategy which deserves attention. In many countries the signs are encouraging and it seems that conservation policies may become more widespread in the coming years.

In conclusion, if technological change and development are to be sustained in the long term, countries need to devise, enact and effectively administer legislation to prevent and control the various types of pollution, and conserve and develop forestry resources, not least to help preserve the world's ecology. They also need to make increasing efforts to substitute non-renewable resources by renewable ones and attempt to slow down the consumption rate of non-renewable resources in order to prolong their availability. Finally, they should enact legislation and devise other mechanisms to promote the culture of recycling and utilising 'wastes'.

Section 7

Regulatory and Other Measures

An integrated legislative policy is a necessary counterpart of a national technology policy. Legal instruments and other regulatory mechanisms can be used to promote, permit or prevent activities, depending upon whether these are or are not consistent with technology policy. There are many such measures, and here we consider seven of them.

Import controls on goods

Most countries employ various policy instruments to control the imports of goods (and services) embodying technologies. As well as customs and revenue duties, non-tariff measures range from import prohibitions on whole sectors,to import quotas on specific goods or countries, import licences, import lists of permissible goods, and import canalisation through State agencies. By determining the types of capital goods and intermediates entering into a country, import controls have an important effect on the technology structure of local industries. They can protect these industries from foreign competition, and thus, in the short term at least, be a powerful stimulus to industrialisation. But in the long term, import controls can distort a country's industrial structure, undermine the development of its industrial S&T, and shield local industries from the need to improve the quality of their goods and the productivity and efficiency of their operations. Most developing countries have applied import controls more to consumer goods than to capital goods and manufacturing inputs, and this, coupled with their generally weak design-engineering capabilities, has meant that the development of their capital goods industries has been generally rather slow.

Technology import regulations

Most countries may prefer to import technologies than finished goods, since the latter can lead to a higher external dependency, greater drain on foreign exchange and less opportunities for local employment. However, indiscriminate import of technology can seriously undermine the growth of local technological capabilities, especially in developing countries whose newly developed technologies often cannot withstand competition from those of the industrial countries. Like infant industries, it may therefore be necessary to give locally developed technologies an opportunity to grow and become strong, before they face competition from the products of industries based on external technologies. At the same time, undue restrictions on technology imports can, as with import controls on goods, create a protected environment in which local S&T institutions and industries may have no compulsion or indeed incentive to develop internationally competitive technologies. Hence, again, restrictions on imports may have two types of effect: whereas in the short run they may protect industries based on indigenous technologies, in the long run, they can make local S&T institutions and industries complacent and incapable of achieving international competitiveness.

With regard to technology licence agreements, it is necessary to ensure that technology suppliers, often the more powerful partners, do not impose restrictive conditions on its use. This is necessary to ensure the transfer of 'know-why' and to raise the speed of the technology's absorption, adaptation and diffusion. The more important restrictive conditions that ought to be avoided in foreign collaboration agreements include:

(i) guaranteed minimum royalty payments regardless of the quantum or value of production;

(ii) restrictions on the procurement of capital goods, components, spares and raw-materials, on pricing policy and selling arrangements, etc;

(iii) restrictions on exports except, perhaps, to the technology suppliers' home-country and others where there are existing subsidiary or licensed units;

(iv) payments to technology suppliers after the expiry of the collaboration agreements except, in some cases, those related to the use of foreign patents, designs or trademarks;

(v) restrictions on sub-licensing of technology to third parties after the expiry of the agreement or, subject to mutual consent, even within its life-time;

(vi) refusal by the licensor to defend the licensee from claims for patent infringement;

(vii) restrictions by the licensor on R&D activities by the licensee or use of the results thereof during the licensing period.

Apart from the above considerations, model agreements for the purchase of technology should specifically state the principal features of the technology to be acquired, the product output, quality and specifications to be achieved, and the technical assistance to be given by the licensor, with details of the manner and timing of its provision. The agreement should also cover, as far as possible, access to any improvements made by the licensor in the technology supplied during the agreement. The licensee should insist on guarantees on the performance of the machinery, equipment and other supplies, including basic engineering services, with compensation for default. The agreements should specify the amounts of all kinds of payments by the licensee to the licensor, the duration of the agreement, the training facilities to be provided, the use of trademarks, and the conditions for terminating the agreement. Lastly, model agreements ought also to include a clause on the governing law for the settlement of disputes (which should preferably be the law of the licensee's country) and an arbitration clause with appropriate details. A large volume of literature[27-30] exists on model agreements for technology transfer and on the restrictive conditions which should be avoided in concluding such agreements.

Foreign investment controls

Most countries have laws or regulations to control foreign investment. In some of them foreign investment to set up enterprises is permitted only if it carries advanced technologies not available in the host countries. However, with acute shortages of capital and foreign exchange, many developing countries have in fact allowed foreign investment even for the manufacture of goods using relatively low-technologies. But with the growth of national identity, even these countries have increasingly regulated foreign investment. India, for instance, enacted a Foreign Exchange Regulation Act in 1974, under which foreign shareholdings of more than 40 per cent are allowed only in respect of companies whose technology is considered sophisticated or which are engaged predominantly in export-oriented manufacturing. Singapore encourages foreign investments in technology-intensive high value-added industries. A fairly large number of countries exclude foreign investment in certain industries, restrict the use of local capital by foreign concerns in some cases, have controls on restrictive business practices and foreign remittances, and so on.

The impact of foreign investment on the technologies of local industries can be very considerable. First, setting up such industries, particularly if they are based on advanced technologies, encourages competition with local firms which then have an incentive to upgrade their technological skills and standards. Secondly, in countries where governments insist on developing backward linkages with the economy through setting up ancillaries or using local supplies of intermediate goods and raw materials, technological diffusion may be promoted. Lastly, the use of technologically advanced products and the associated requirements of maintenance and repair facilities may also promote the local development of new skills.

Foreign investment, if carefully regulated, can therefore be a strong inducement for industries in host countries to upgrade their products and improve their technological skills, as well as being a powerful stimulus to technological change worldwide. However, in developing countries it is often necessary not only to protect traditional skills and capabilities, but also to restrict foreign investment to carefully identified sectors, in order to give local technological capabilities a chance to grow and develop,

Investment licensing policies

Many countries have measures for licensing new industries, particularly those which need substantial investment. Such measures fulfil a multiplicity of objectives. As the availability of investment capital is limited, especially in developing countries, many governments find it necessary to regulate the flow of investment. National plans make demand projections for goods and services required for internal consumption or export, and governments may attempt to tailor production capacities to fulfil these demands. Regional dispersal and diversification of industries and other economic activities may be encouraged and the use of appropriate, environmentally sound, and internationally competitive, technologies promoted. There are many other objectives, including import-substitution, export-promotion and employment-generation, which can be promoted with licensing mechanisms. The objects of licensing policy are, in fact, diverse and sometimes diffuse. Although the licensing and associated registration mechanisms generate much useful information, it is difficult to evaluate their impact on the management of technological change. This seems to vary according to the primary objectives and related aspects involved in the formulation of licensing policies; but it also depends on other considerations (including politics) that enter into the decision-making process. Nonetheless, licensing policies can be used to influence the pace, magnitude and direction of technological change.

Competition policy

The need for a competition policy seems to have been recognised more in industrial countries than in others. Such policies can spur industrial units into upgrading their technologies, reducing their costs, and raising the quality and performance of their products. However, whereas many countries have such instruments as anti-dumping laws, controls on the activities of large or dominant undertakings, and prohibition of restrictive business practices, few of them have adopted policies to encourage competition specifically as a way to improve the quality and efficiency of their industrial sector. Lack of a competitive environment in many countries has not only retarded the pace of technological advancement but also adversely affected the consumer interests. It is important that competition policy should take care of the above-mentioned negative aspects and, perhaps more importantly, that it should create a competitive environment for fostering technological change. This could involve the deliberate, but careful, encouragement of intra-plant, inter-plant and international competition. Both public and private sector units, particularly those at present with a monopoly, need to be subject to competition, from within and outside the country, so as to promote the greater productivity of their operations and the higher quality and performance of their goods and services. Development of internationally competitive technologies in selected sectors should be a major goal of competition policy.

Mandatory standards and norms

Technical standards and norms are a means of introducing uniformity into dimensions and other specifications, levels of quality and performance, and other parameters in goods (and services). They can also foster competition, reduce inventories, improve and diffuse technologies, and protect consumers. The last of these is particularly important for such items as food, drugs and consumer durables (especially electric appliances and cars), as well as in protection from pollution (e.g. from thermal electricity generating plants). Given their wide-ranging benefits, all countries should make more effective and widespread use of mandatory standards and norms.

Patents and trademarks

Patents and trademarks are the main legal instruments for the regulation of industrial property. A patent is a legally enforceable right granted to an entity by the appropriate governing authority,which excludes, for a defined period, others from certain acts subject to the fulfilment of conditions prescribed by the patent-holder. The concept of trademarks is well understood, and needs no definition here.

Many countries exclude specific sectors of special concern from patent laws; they often exclude atomic energy, drugs and medicines, and food. Others, however, merely grant a shorter period for patents in these sectors. In India, for instance, while patents are generally valid under the Patents Act, 1970 for 14 years, the valid period for food, drugs and medicines is only seven years. The absence of patent rights could retard the generation of new knowledge involving substantial amounts of

R&D, since, by allowing anyone to copy the patented product, the incentive for its commercial exploitation would be lost. Granting patents to foreigners and not discriminating against them (as laid down by the Paris Convention for the Protection of Industrial Property Rights) is also necessary to promote the flow of goods and technologies from patent-generating countries to others. On the other hand, most countries' patent laws usually provide for compulsory licensing if the patented know-how is not transferred by the patent-holder to any other party in the patent-granting country within a prescribed time. Compulsory licensing may also be used to avoid imports into patent-granting countries of goods covered by the patent. Finally, revocation of patents by the State can be used to compel patent-holders to license their know-how at reasonable prices to other parties. This action is specially useful where patent-holders fail to fulfil specified obligations.

The association of trademarks with particular manufacturers or distributors and with the performance and quality of their goods is widely used to promote sales, both in internal and export markets. The exhibition of trademarks can be useful inasmuch as it makes it easier to identify particular goods, especially those of certain specified characteristics. However, foreign trademarks often enjoy a psychological advantage over those of local enterprises, particularly in developing countries, which can depress the latters' sales even though their goods may often reach the standards of those with foreign trademarks. It is for this reason that some countries (including India) do not generally permit the use of foreign trademarks for internal sales.

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