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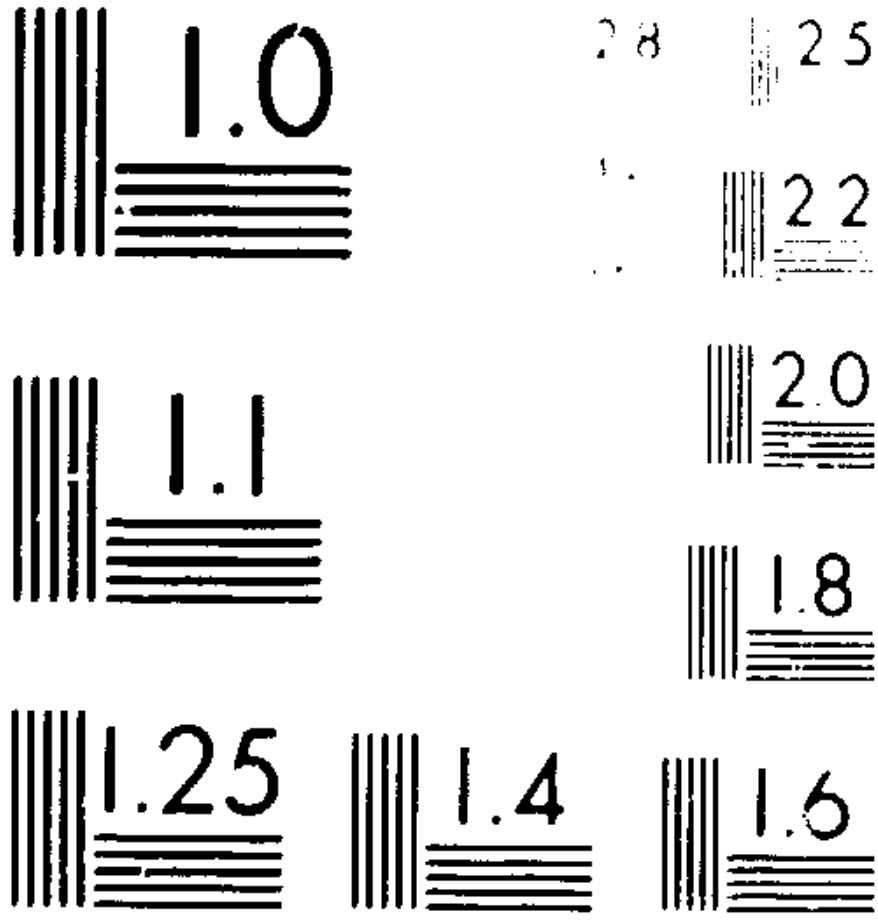
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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

Development and Transfer of Technology Series

No. 15

TECHNOLOGICAL SELF-RELIANCE OF THE DEVELOPING COUNTRIES: TOWARDS OPERATIONAL STRATEGIES

1981

UNITED NATIONS

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TECHNOLOGICAL SELF-RELIANCE OF THE DEVELOPING COUNTRIES: TOWARDS OPERATIONAL STRATEGIES

Explanatory notes

ECDC Economic Co-operation among Developing Countries
TCDC Technical Co-operation among Developing Countries

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Introduction

As part of its preparatory activities for the United Nations Conference on Science and Technology for Development held in Vienna in August 1979, UNIDO convened in Vienna in June 1979 the Expert Group Meeting on Technological Development and Self-Reliance in Developing Countries. The Meeting was a continuation of an examination of the issues of technological development that had emerged from the International Forum on Appropriate Industrial Technology held at New Delhi and Anand, India, in November 1978. The Meeting endeavoured to define technological self-reliance, and to consider what operational strategies would realize it. This report is based on the viewpoints expressed, and the papers presented at that Meeting, and has been prepared with the assistance of the Foundation Reshaping the International Order (RIO), a non-profit organization whose headquarters are in Rotterdam, the Netherlands.

It is proposed to follow up this Meeting by a series of studies, at the field level, of the factors that have promoted or inhibited the achievement of technological self-reliance in developing countries. Later, the experience gained will be examined at expert and policy level meetings.

The strengthening of domestic technological capabilities in the developing countries is essential not only to the rapid acceleration of their social and economic development but also to overcome their excessive technological dependence on the industrialized countries. A recognition of this is reflected in various institutional arrangements in many developing countries designed to control technology imports and to promote technological development and innovation. These arrangements are supported by new programmes launched under the auspices of the United Nations.

The concept of technological self-reliance is not well understood and strategies aimed at strengthening autonomous technological capabilities encounter many obstacles both nationally and internationally. The purpose of the Meeting was to review some of the problems associated with the promotion of national technological self-reliance and to identify the major elements in the design and implementation of strategies aimed at strengthening indigenous technological capabilities. To this end, the Meeting set out to analyse the extent and nature of the constraints imposed on the development of autonomous capacities by the present international technology system and to identify the principal ingredients of technology development programmes. The Meeting also gave special attention to the overall policy framework, institutional arrangements, linkages and skill development to enable the effective acquisition, adaptation and absorption of imported technologies on the one hand and the rapid growth of national capacities to innovate on the other.

The Meeting was opened by the Executive Director of UNIDO who pointed out that more effective use, control and development of technology were necessary in order to attain the economic and social goals of development and in order to ensure that the developing countries were able to achieve the Lima target of increasing their share of world industrial output from its present level of under 10 per cent to 25 per cent by the year 2000.

O. A. El Kholy was elected Chairman of the Meeting and Anthony J. Dolman was elected Rapporteur.

The Meeting noted that UNIDO had recognized the importance of the role of technology in the process of national development; it had produced technology guides, established an Industrial and Technological Information Bank and Information Services and had a section for the study of problems in the development and transfer of technology. Its interest was shared by other agencies in the United Nations system, such as UNESCO in science and education, UNCTAD in trade and development, FAO in agriculture and the United Nations Centre on Transnational Corporations. In all those fields, industry and industrial products were of fundamental importance.

The Lima target had been given central importance by the developing countries in their efforts to bring about a new international economic order. The attainment of the Lima target called for a ninefold increase in the industrial output of the third world. Capital and manpower constraints would obviously make it difficult to achieve such an increase. The adaptation, absorption and development of technologies no doubt had a decisive role to play in reducing investment requirements and in maximizing production. It followed that technology could and should be a prime motive force of development rather than a passive follower.

I. Technological dependence of the third world and limitations of the present technology system

A. Technology and development

Technology is one of the prime motive forces of development. Whether the need is more food, better education, improved health care, increased industrial output or more efficient transportation and communications, technology plays a decisive role. It consists of a system of knowledge, skills, experience and organization that is required to produce, utilize and control goods and services. Technology is critical to development because it is a resource and the creator of new resources, is a powerful instrument of social control and affects decision-making to achieve social change.[1]

Technology is not neutral; it incorporates, reflects and perpetuates value systems and its transfer thus implies the transfer of structure.[2] Technology is both an agent of change and a destroyer of values. It can promote equality of income and opportunity or systematically deny it. It follows that technology not only influences society but also that society imposes limits on the choice and development of technology.

Because the technologies adopted by the developing countries not only shape national development options but also affect, directly and indirectly, the economic structure of the industrialized countries, it is not surprising that technology is of concern to both rich and poor countries. Inevitably, it has become one of the major areas of negotiation for the establishment of a new international economic order.

B. Technological dependence of the third world

Although aware of the great importance of technology for their development, the developing countries are unable to exercise real choice in designing effective strategies for their technological transformation. The growth of the international economic system has resulted in a profusion of institutions and mechanisms that maintain developing countries in conditions of dependence and that lead to ever-widening disparities between the richest and poorest nations.

Industrial production in the industrialized world has been accompanied by a process through which the sources of new technology have been concentrated and a handful of enterprises and government agencies dominate and control most of it. For example, in the United States of America the top 50 corporations and the government research agencies in the fields of defence, energy, space and health accounted for more than three quarters of the $38 billion spent on research and development in 1976. A few hundred people in the highly industrialized nations are able to make decisions on who is going to get which part of these new technologies at the world level and under what conditions.[3]

Nowhere are the disparities between the industrialized countries and the third world more marked than in the crucial field of technological development: the dependence is almost total (table 1). Developing countries possess only 12.6 per cent of global stocks of scientists and engineers engaged in research and development (R and D), of which 9.4 per cent are concentrated in a few countries of Asia. Developing countries account for only 2.9 per cent of global expenditures on R and D and 3.3 per cent of global exports of machinery and transport equipment. There are no readily available data for services but there is little reason to suppose the picture would be much different. Approximately 95 per cent of developing countries' imports of machinery and transport equipment come from developed countries.[4]

In general, technological dependence arises when most of a country's technology comes from abroad and the greater the reliance on foreign technology and the more concentrated the source, the greater the dependence. For the developing countries, the major

[1] See Denis Goulet, *The Uncertain Promise: Value Conflicts in Technology Transfer* (New York, IDOC/North America, 1977), pp. 7-12.

[2] See Johan Galtung, "Development, environment and technology: towards a technology for self-reliance" (TD/B/C.6/23), June 1978.

[3] Francisco R. Sagasti, "Knowledge is power", *Mazingira*, No. 2, 1979, p. 28.

[4] See *Industry 2000, New Perspectives* (ID/237), pp. 180-182.

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TABLE 1. SELECTED INDICATORS OF TECHNOLOGICAL CAPACITIES

Indicator	Developed market economy countries	Eastern Europe (including USSR)	Developing countries		
			Africa	Asia	Latin America
R and D scientists and engineers, 1973 (percentage of world total)	55.4	32.0	1.2	9.4	2.0
R and D expenditures, 1973 (percentage of world total)	66.5	30.6	0.31	1.63	0.94
Share of exports of machinery and transport equipment, 1976 (percentage of world total)	86.9	9.5	0.04	2.6	0.68
Developing country imports of machinery and transport equipment, 1971 (percentage of total)	90.3	4.2		5.1	

Source: UNIDO, *Industry 2000. New Perspectives* (ID/237), tables 7 (1) to 7 (4).

source is a small number of industrialized countries. A country dependent upon a single source for all of its foreign technology can thus be considered more dependent than one that obtains its technology from a range of countries. For some technologies, sources may be widely spread; for others, for specific industries, they may be highly concentrated. At present, the United States is the world's main supplier of technology, being responsible for 55-60 per cent of the world's technology flow.[5]

Third world countries cannot offset the direct costs of technology imports with the proceeds of technology and exports of manufactures.

Many developing countries suffer "double dependence" in that they need not only to acquire the elements of technical knowledge but also to import the capacity to use this knowledge in investment and production.

Technological dependence seriously undermines the attempts that might be made by a developing country to strengthen its own capacity for scientific research and technological development. It does so in two ways: it inhibits processes of "learning-by-doing" essential for the development of scientific capacities; and it tends to devalue the activities of local scientific and technology institutions, making them either irrelevant or poor copies of those in the industrialized countries.

C. Limitations of the present technology system

The international system with its built-in, automatic mechanisms that maintain dependencies imposes severe constraints on the exercise of the technological options open to the developing countries. Some of the most severe of these constraints are the costs of technology transfer; the role of transnational corporations in the transfer process; the relevance of the technology transferred; and the restrictions imposed by the international industrial property system.

Costs of technology

During the last two decades there has been a rapid growth of technology exchange between enterprises in different countries and an emergence of industrial technology as a highly marketable commodity. Trade in technology rose from approximately $2.7 billion in 1965 to over $11 billion by 1975, mainly in the form of lump-sum payments, royalties and fees. Most technology trade has taken place between enterprises in the industrialized countries, with the highest outflow coming from the United States, followed by Switzerland, the United Kingdom of Great Britain and Northern Ireland, the Federal Republic of Germany, the Netherlands, France, Belgium, Italy and Japan. The payments made by the developing countries for transactions in technology are estimated at $1 billion in 1975 which is less than 10 per cent of the total value of such transactions. Of this amount, about 50 per cent was paid by Latin American countries, particularly Brazil and Mexico, and about 35 per cent by Asian countries. Payments to United States enterprises from developing countries accounted for $316 million in 1965, increasing to $845 million in 1975.

In a perfect market, competition would reduce to marginal the cost of acquiring technology; the market in technology, however, like so many others of importance to the developing countries, is imperfect, with great monopoly advantages for the seller because of secrecy and the protection of patents and trade marks. The technology (whether in the form of pure knowledge or embodied in foreign investment or machinery) is transferred under terms that are the outcome of negotiations between buyers

[5] See "Technological cooperation between developing countries including exchange of information and experiences in technology and know-how arrangements" (ID/WG.272/1), p. 3.

and sellers in situations frequently approximating monopoly or oligopoly. The final returns and their distribution largely depend upon the relative power of the bargainers and an unfavourable outcome is probable for the dependent countries.

UNIDO has estimated that the trade in technology by developing countries, in terms of fees, royalties and other payments for technical know-how and specialized services, could increase from approximately $1 billion in 1975 to over $6 billion by 1985.[6] This is approximately 15 per cent of the total trade in technology which, if the growth in the period 1965-1975 is maintained in the period 1975-1985, is likely to be approximately $40 billion by the mid 1980s. Most of the payments made by developing countries would be for technology and know-how imported from the industrialized countries and would represent payment outflows by the third world as a whole. The figure can, however, be considered an under-estimate since it takes no account of underpayments through the manipulation of transfer prices or the cost of technology transferred implicitly via sales of product and payments for foreign personnel.

The indirect costs of technology acquisition, which take the form of restrictions on sources of input and access to market outlets, are held to be many times higher than direct costs. Rough estimates indicate that indirect and hidden costs could be from $6 billion to $12 billion a year, equivalent to 2-4 per cent of the national income of the developing countries.

Although the total cost of the technological dependence of the third world cannot be accurately stated, if allowance is made for the transfer of inappropriate technologies and the long-term influence of technologies that undermine the development of endogenous capabilities, it could well be as high as $30 billion to $50 billion a year.

Role of transnational corporations

Transnational corporations have been responsible for approximately 80-90 per cent of the technology transferred to the developing countries and much of the third world has been dependent upon transnationals for acquiring and expanding their technological development capability.[7] This has mainly involved "contractual transfers", the main way of acquiring the technologies required for such science-intensive industrial sectors as chemicals, pharmaceuticals and electronic components.

The use of transnationals as a major source of technology has given rise to many problems. Confusion over basic values and social priorities has often led to the uncritical purchase of technologies and techniques and this has in many cases proved detrimental to genuine development. The indiscriminate extension of the technologies and the productive systems employed by transnationals into the third world has resulted in much destruction of traditional technologies as well as social problems. It has been clear that the development fostered by transnationals, especially those involved in consumer goods industries, is not always responsive to social needs, particularly those of the poor. Because of their necessity to continually expand and grow, transnationals must have an increasing number of responsive buyers. Since their capacity to sell largely determines their profits, they must inevitably produce for those who can afford rather than those in need. Thus, they have become linked to and dependent upon the affluent sectors of poor societies because these are the principal consumers. When allowed to operate on the principle of artificially stimulated demand, and thus waste, it is inevitable that they tend to repeat the patterns of Western market economy societies through a type of technology very often inappropriate to the needs of third world countries.

The market power of transnational corporations largely determines the availability and pattern of technology transfer in advanced science-based sectors where technology ownership is mainly concentrated in a few large enterprises. In these sectors, owing to increasing R and D costs, the economies of scale involved in technological innovation and commercialization, and high costs of market failure, large companies have become the major source of technological development and, consequently, the owners of improved and new technology. Similarly, in sectors where fast technological change reduces the product life cycle, for example, drugs, scientific instruments and electronics, the importance of technological advantage makes control over the technology within the corporate system the major motivating factor in its commercialization. In these sectors, the transfer of technological know-how is confined largely to wholly or majority-owned subsidiaries. Where foreign minority ownership is unavoidable, effective control over technology use is sought through management or service contracts. The diffusion of technology in these advanced sectors and the participation by competitive firms is frequently limited, on the one hand, by a large degree of cross-licensing, patent pooling and other forms of technology sharing arrangements between the leading transnationals and, on the other, by intra-firm technology flow. Such barriers have been particularly prevalent, for example, in the chemical industry and in the manufacture of heavy electrical and telecommunications equipment.

Despite the regulatory measures instituted by several developing countries and the increased

[6] See "Towards a strategy of industrial growth and appropriate technology" (ID/WG.264/1), p. 4

[7] See "Technological cooperation between developing countries . . .", p. 3.

availability of technological alternatives in certain sectors, the role of transnational subsidiaries and affiliates in most developing countries is important because of their dominant position in several sectors, for example, the pharmaceutical industry (table 2). In most countries of Africa and Latin America, mineral industries remain largely under foreign ownership or control even though domestic participation, often through state enterprises, has been increasing in recent years. State participation and control have been most marked in the petroleum industry, but in both petroleum and other resource-based industries, transnational corporations have continued to exercise significant control through the supply of technology and services. In several developing countries, even relatively low-technology consumer goods production has remained under the control of foreign subsidiaries. In the case of middle-technology and high-technology industrial sectors, transnational subsidiaries and affiliates exert dominant influence even in such countries as Brazil, India and the Republic of Korea where significant domestic entrepreneurial capability exists. In several service sectors, including merchandising, transnational subsidiaries and affiliates continue to play a decisive role in many developing countries.

TABLE 2. ESTIMATED FOREIGN-CONTROLLED SHARES OF THE PHARMACEUTICAL INDUSTRY–SELECTED COUNTRIES, 1975

Country and groups of countries	*Share of sales (percentage)*
Saudi Arabia	100
Nigeria	97
Belgium	90
Colombia	90
Venezuela	88
Brazil	85
Canada	85
Australia	85
Indonesia	85
Mexico	82
Central American Common Market (1970)	80
India	75
Iran	75
Argentina	70
United Kingdom	60
Italy	60
South Africa	60
Finland (1971)	50
Sweden	50
France	45
Portugal (1970)	44
Turkey (1974)	40
Norway (1971)	36
Germany, Federal Republic of	35
Switzerland (1971)	34
Greece	28
Egypt (1971)	19
United States	15
Japan	13

Source: For details of sources see "Transnational corporations and technological development" (ID/WG.301/12), p. 35.

Transnational corporations have generally contributed little to the development of technological infrastructure in the developing countries. Rather, they have sought to minimize the value-added of their production in a developing country. This procedure has frequently been aggravated by the excessively high prices at which some technological know-how is supplied by so-called "tie-in" clauses. Since proprietary and non-proprietary knowledge is transferred by a transnational corporation partly in embodied form or as know-how from the parent company, there is little interest or initiative for R and D activities by subsidiaries and affiliates. Since affiliates obtain only those elements that have already been commercialized in the home market, the R and D function has been completed for the specific technology at the parent company. New technologies, including improvements, are developed in the parent company, which is close to the home market and has an advanced scientific and technological infrastructure. Centralization of technology generation at the parent company also helps to ensure control over proprietary technology. Local R and D activity in developing countries is often confined to the adaptation and local testing of products that are not available in the industrialized countries, such as certain drugs, or that are only produced locally, such as tea processing. The absence of R and D in the host country renders the affiliate dependent on the parent company for the flow of technological improvements. This inevitably becomes a major element of control. Technology ownership can be similarly the controlling element in the case of joint ventures, particularly when technology transfer includes patented know-how brands or trademark names.

The lack of local R and D activity and the resultant low demand for scientific and research personnel hinders the development of indigenous engineering and design capabilities necessary for the creation of technology and the effective adaptation and absorption of foreign technology. Moreover, in the absence of local R and D the affiliate has little technological linkage with local scientific and research institutions, which would promote technological research capability and diffusion.

Given the above, it is inevitable that transnational corporations have provided but little employment in the developing countries. Estimates vary from 1.6 million to 2.5 million for 1967 for all industrial sectors combined, approximately 0.3 per cent of the third world's total active population. Even when generous allowances are made for the indirect employment created, this figure is insignificant.

The transfer of technology from the parent company to foreign affiliates, because it takes place as a purely internal process, provides opportunities to manipulate the prices of goods and services supplied

by one part of the enterprise to another. Internal transfers have been used, for example, to shift profits and to control "free" cash. The extent to which transnationals manipulate transfer prices appears to depend upon the gains *vis-à-vis* the costs, in terms of the effort and risk involved. Manipulated prices are most likely where large corporations trade in large quantities in products encountering little or no competition. The potential for such manipulation appears likely to increase as a result of the continued concentration of economic power in the hands of transnationals and the increasing importance of intra-corporate transactions in their total trade, and in particular of the continued diversification of their activities on a horizontal, vertical and conglomerate basis.

The problem of transfer pricing is one that confronts both industrialized and developing countries. However, inducements to manipulate prices may be greater in the countries of the third world. This is owing to, among other things, import controls, limits on dividend remittances and royalty payments, and the desire by transnationals to achieve, for a variety of reasons, a higher return on investments. Intra-firm trade probably exceeds 50 per cent of the international trade transactions of the developing countries, and case studies show that the extent and range of intra-firm imports of developing countries are large, especially in such industrial sectors as chemicals, pharmaceuticals, electrical machinery and rubber.[8]

Transfer price manipulations can seriously prejudice a developing country's possibilities for economic development: they can, for example, have adverse effects on competition and the balance of payments, domestic capital formation, tax revenues of individual developing countries, and local industrial structure.

Transnationals are expressions of a system whose values and orientations have given them their characteristics and stimulated their unprecedented expansion.[9] Transfer pricing is a function of the corporate system and it may prove exceedingly difficult to change transfer arrangements without first changing corporate structures. Transfer pricing may well be an area in which the power of transnationals is greater than that of governments to control it, although government supervision, especially of the industrialized countries, has so far been minimal.

Relevance of the technology transferred

Much of the technology developed in the industrialized countries has little direct relevance to the problems confronting many developing countries because it is not geared to the satisfaction of basic human needs; more than 50 per cent of world investment in science and technology is directed towards the production of ever more sophisticated weapons and armaments and about two thirds of the remainder towards marginally increased consumption of non-essential goods.[10] Research on problems directly relevant to the third world probably accounts for little more than 1 per cent of the total research expenditures of the industrialized countries.

Most of the world's ready-made technologies are optimally suited to the industrialized countries. The introduction of inappropriate Western technologies has had a wide range of consequences for the developing countries, particularly those noted below.

Although some Western technology has undoubtedly contributed to economic and social progress, in many developing countries it has been instrumental in increasing the gap not only between rich and poor, but also, in earnings and social status, between men and women. This is especially so with some of the "modern" technologies introduced by transnationals. Although these enterprises can be powerful engines of growth, their activities are not inherently geared to the goals of development and, in the absence of proper governmental policies and, in some cases, social reform, tend to increase rather than reduce inequalities in poor societies.

Technology is not a neutral factor in social and economic development; various types of technologies can be used to promote different types of development and to reinforce patterns of privilege and power. Western technologies have been used by developing country élites to strengthen their power position at a time when self-reliant development calls for increased participation and the decentralization of decision-making functions.

One of the reasons why Western enterprises have sought to establish affiliates in the developing countries is to escape the increasingly strict pollution control legislation in their home countries. Some developing countries have implicitly acquiesced to the use of their "open spaces" as pollution havens although it is increasingly being realized that development that is in harmony with the environment can contribute, especially at the local level, to the satisfaction of basic needs and the promotion of self-reliance.

International industrial property system

International patenting does not itself generate technological dependence. It is, however, a means of regulating the application of technological knowledge in different countries and by different types of enterprises. The international patent system thus

[8] See UNCTAD, *Intra-firm Transactions and the Impact of Development*, UNCTAD Seminar Programme, Report Series No. 2 (May 1978).

[9] *The Impact of Multinational Corporations on Development and International Relations* (United Nations publication, Sales No. E.74.II.X.S.), p. 162.

[10] See Sagasti, *loc. cit.*, p. 28.

exerts considerable influence on who gets industrialized, and the method, conditions and cost.

Patents confer on the owner a monopoly of production and distribution of products in a specified territory for a given period of time. Of the current 3.5 million patents, only approximately 200,000 (6 per cent) have been granted by developing countries. Of these, moreover, five out of six are held by foreigners (table 3) and only one sixth (1 per cent of the world total) are held by nationals of the developing countries. Most of the developing country patents held by foreigners are held by large corporations headquartered in five developed market economy countries: the Federal Republic of Germany, France, Switzerland, the United Kingdom, and the United States. Approximately 90 to 95 per cent of the patents granted by developing countries to foreigners are not actually used in production processes in those countries; instead, the overwhelming majority are used to secure import monopolies. In some cases, utilization rates fall below 1 per cent of the registered patents. In Peru in 1975, the patent utilization rate was below 0.5 per cent.[11] It is thus evident that international patent practices have come to represent a reverse system of preferences granted to foreign patent holders in the markets of developing countries.

TABLE 3. SHARE OF PATENTS REGISTERED BY NON-RESIDENTS IN SELECTED DEVELOPING COUNTRIES

Country	*1965*	*1970*	*1975/76*
Argentina	...	77.7	69.2
Bolivia	...	89.5	86.7
Chile	91.5	93.8	89.5
Colombia	93.4	80.8	78.6
Ecuador	...	96.3	86.7
Ghana	100.0	100.0	100.0
Hong Kong	...	98.6	98.8
India	90.2	83.1	82.6
Iran	93.1	92.7	96.8
Kenya	100.0	100.0	100.0
Korea, Republic of	38.7	25.1	32.5
Morocco	93.5	94.5	93.5
Philippines	96.0	96.5	87.6
Tanzania, United Republic of	100.0	100.0	100.0
Tunisia	95.6	99.3	91.6
Venezuela	94.5	92.0	84.5
Zaire	100.0	100.0	92.5
Zambia	...	99.4	98.0

Source: Based on *Industrial Property* (Geneva, WIPO, 1977).

Even when foreign-held patents are actually used in production processes, the agreements entered into by developing countries concerning patent use through foreign investment or licensing arrangements frequently contain high royalty payments and charges for the technology, restrictive practices and in some instances abuses of patent monopolies, either explicitly embodied in the contractual agreements or implicitly followed by subsidiaries and affiliates of transnational corporations, which impose heavy indirect or "hidden" costs by overcharging for imported inputs. The foreign exchange burden of these costs, which are much larger than direct costs, applies to all developing countries regardless of whether they have national patent laws.[12]

The extensive patenting activity of Western transnational corporations has undoubtedly suppressed the development of local innovative activity and has contributed to a continuous decline in the share of locally owned patents. This trend is demonstrated in the example of Chile (table 4), which is characteristic for most developing countries for the past decades. The insignificantly low share and economic importance of locally held patents tend to demonstrate that the present industrial property system has hampered the development of indigenous technological capabilities.

TABLE 4. SHARE OF PATENTS REGISTERED BY FOREIGNERS IN CHILE

Year	*Percentage*
1937	65.5
1947	80.0
1958	89.0
1967	94.5
1976	90.0

Sources: C. V. Vaitsos, "Patents revisited: their function in developing countries", *Journal of Development Studies*, vol. 9, No. 1 (October 1972); *Industrial Property* (Geneva, WIPO, 1977).

Summary

The suppliers and purchasers of technology have different motivations and hence obey different criteria.

The suppliers seek lucrative, free and diverse markets in which they can generate revenues on their investments in R and D. In carrying out their activities they exploit international financing contracts, and become involved in measures against competitors and in countering national pressures over ecological and working conditions. The purchaser of technology, on the other hand, wants to master the imported technology, exploit it to develop his country and remain competitive domestically and internationally.

In this conflict of interests, the weaker partner, which is often the developing country, is destined to lose. The technology supplier is able to take

[11] M. A. Zevallos y Muniz, *Análisis Estadístico de las Patentes en el Perú* (Lima, Consejo Nacional de Investigación, 1976).

[12] "The role of the patent system in the transfer of technology" (TD/B/AC.11/19/Rev.1), p. 64.

advantage of a wide range of weaknesses of the recipient country, including a lack of capital and of appropriate skills and information.

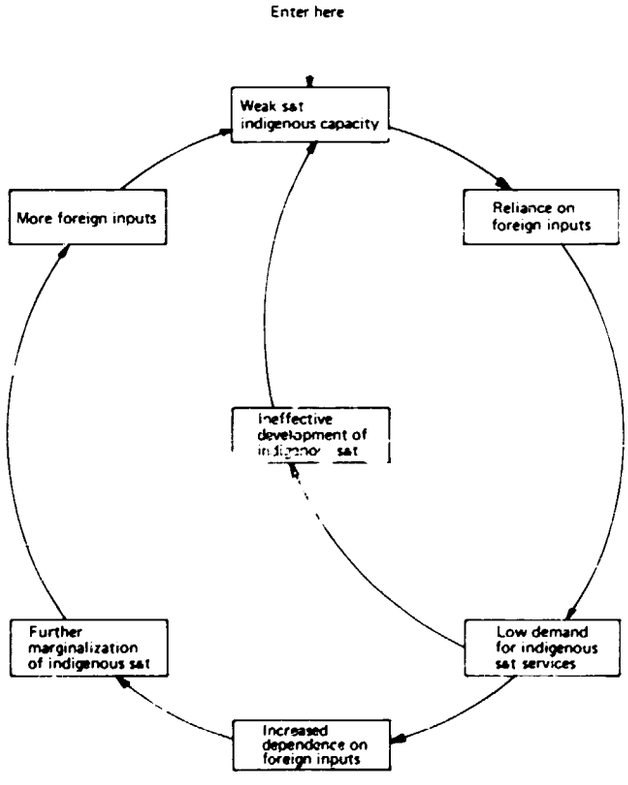
The transfer of technology from the industrialized countries has enabled some developing countries, particularly the more privileged groups within them, to benefit from some of the advances made in the field of science and technology in the past two centuries. The transfer has allowed these countries to use this technology without themselves having to go through the difficult and costly process of developing it. Technology transfer has introduced high-productivity techniques, and also, in many cases, inspired the desire for technical change. Whereas there are some benefits from the present system of transfer, there are none from the dependence that the process of technology transfer, development and concentration has created.

Technological dependence has many dimensions; at its simplest, it results from the fact that a handful of rich countries are the source of almost all the industrial technologies that are currently being applied, and that the virtually sole supplier of technologies has been transnational enterprises, which are motivated by business (profit-maximization) rather than development (social welfare) considerations.

At another level, technological dependence is one aspect of the general pattern of dependence resulting from the operation of the international economic system and the institutions and mechanisms that govern the relations between rich and poor countries. The international economic system is a stratified system of power relations. Because it has a structure that helps to determine who decides and who controls, it is a system of domination.

Rather than reducing the technological dependence of the developing countries, the international system actively and persistently reinforces it. The transfer of technology may facilitate the expansion of industrial output in the developing countries; it does not, however, necessarily further the ability of these

Figure I. The "vicious circle" of technological dependence



Source: "The structure and functioning of technology systems in developing countries" (ID/WG.361/2), p. 43.

Note: s & t = science and technology.

countries to produce that output, or, more precisely, does not give them the capacity to adapt and modify existing technology or to evolve new technologies.

Technological dependence can be seen as both cause and effect of general dependency relationships.[13] It leads to foreign investment, loss of control and the introduction of alien patterns of consumption and production. This creates an enclave economy, dependent on the advanced countries for inputs, markets, management, finance and technology. This creates, in its turn, a society in the image of the advanced countries, requiring further imports of technology to satisfy new demands and to enable the industries to survive and expand. There is a vicious circle in which a weak technology system reinforces dependence, and dependence perpetuates weakness. Some of the elements of this vicious circle are shown schematically in figure I.

The international system and the channels through which technology is transferred to the developing countries thus contain many elements that are incompatible with the attainment of many of the objectives of the New International Economic Order, including the industrialization target contained in the Declaration and Plan of Action of the Second General Conference of UNIDO held at Lima in 1975. The use of existing channels for the attainment of this target—an increase in the third world share of industrial output from its present level of under 10 per cent to 25 per cent by the year 2000 could, according to some estimates, increase by fivefold to eightfold the costs of technological dependence. As noted earlier, these approximate costs may already be from $30 billion to $50 billion a year.[14]

The present technology system thus maintains the developing countries in a situation of dependence and frustrates efforts that might be made to develop an indigenous technological capability. It is clear that there is a need for a new approach based upon revised premises and objectives.

[13] Frances Stewart, *Technology and Underdevelopment* (London, Macmillan, 1977), p. 138.

[14] See Surendra J. Patel, "Plugging into the system", *Development Forum*, October 1978.

II. Towards technological self-reliance: issues and implications

A. Towards technological self-reliance

The new approach to the technological transformation of the third world must aim at reducing the technological dependence of the developing countries by strengthening their autonomous capacity for technological change and innovation. This approach, a movement away from a "flow" concept to a "stock" concept, must necessarily be supported by determined efforts to restructure the prevailing legal and juridical environment with the aim of developing new sets of internationally agreed norms for the benefits that arise from the international transfer of technology. Such restructuring should focus on the formulation of appropriate codes that can be used to control transfers and the activities of transnational corporations and on the reform of the industrial property system in order to create the necessary conditions for strengthening the endogenous technological capabilities of the developing countries and for reducing their dependence.

Technological autonomy, although a particularly important component of self-reliant development, cannot, under the present global circumstances, mean technological independence. Just as national self-reliance may require selective participation in the international system, enhanced technological autonomy may necessitate selective technological delinking from the world market, however difficult this might prove. Some scientists in the third world argue that the poor countries should cut themselves off from Western science and technology, that traditional cultures "must be protected from the onslaught of Western patterns of consumption and those consumer goods that represent the omnipresence of technologies". By the same token, the developing countries "should reject all Western offers of technological assistance".[15]

Whereas structural disengagement could in some instances have an unexpectedly stimulating effect on the development of local technological capabilities, it appears to be an option open to only large developing countries. Even for these, however, it will be difficult to ignore the fact that the international economic system is the dominant system that governs the behaviour of subsystems. The Union of Soviet Socialist Republics has been seeking ways in which it can strengthen its links with the market economies, and China is also carefully exploring such possibilities. Clearly then, disengagement is bound to be difficult for most developing countries. Besides, autonomous capacity for technological development does not mean that a country must reinvent the wheel. Rather, it means that it should have the capacity to do so if it had to, possibly in circumstances beyond its control, and have the capability to improve upon wheels invented elsewhere.

Technological self-reliance is defined as the autonomous capacity to make and to implement decisions and thus to exercise choice and control over areas of partial technological dependence or over a nation's relations with other nations. It follows that technological self-reliance can be effectively pursued only when a nation understands the nature and extent of its technological dependence and possesses the will and self-confidence to seek to overcome it and to maintain its cultural identity. Technological self-reliance must thus be conceived in terms of the capacity to identify national technological needs and to select and apply both foreign and domestic technology under conditions that enhance the growth of national technological capability. Enhanced technological capacity appears to be an essential precondition for developing countries to deal with their economic and social problems.

B. Dimensions of technological self-reliance

There is an enormous variety of technological situations in the third world and generalizations concerning strategies may have little relevance. The decisions that must be taken by developing countries will be determined by such considerations as factor endowments, cultural patterns, national aspirations, present levels of development and industrialization (sectors, products, processes, functions performed in productive operations), geographic location, size of markets, and so on.

In seeking to exercise their limited choices, developing countries will be constantly confronted with complex problems that defy quick solutions. A

[15] "Separate development for science", *Nature*, vol. 277, May 1978.

major problem will almost inevitably concern the science and technology system. The behaviour of this system is conditioned by the larger social system of which it forms part. A science and technology system has various components such as institutions (scientific and technological) and production facilities, supported by infrastructure comprising finance, physical facilities and human skills all of which are embedded in, and which affect, a pattern of values. The technology system performs several functions starting with a specification of its "outputs" (products and services) and proceeding to choice of technologies in the usual sequence of prefeasibility, feasibility studies, engineering design, implementation, management, marketing and R and D. As the components in the technology systems of some nations are more developed than those in others, there are differences in the ability to perform various functions.

There appears to be fundamental differences in the science and technology systems in industrialized and developing countries. In the industrialized world—whether as a result of an internal cumulative process, as in the case of Western Europe, or of a transplant that grew its own roots, as in the case of the United States and Japan—the evolution of scientific activity has led directly to, or is clearly linked with, advances in production techniques. In the developing countries, knowledge generating activity is often, for various reasons, not related in any significant way to productive activities. Industrialized countries might thus be described as possessing an endogenous scientific and technological base, and developing countries as having an exogenous scientific and technological base.[16] The process of interaction between science and production is complex and took place among considerable social upheavals, and concurrently with the emergence of capitalism as the dominant mode of production.[17]

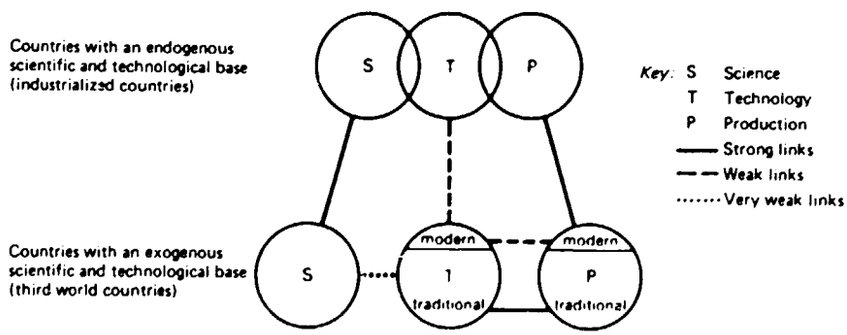
The technology systems in most developing countries are characterized by "dualism": the existence of a modern, urban enclave linked to the international market place, usually producing for and adapting to the needs of the industrialized countries, within a traditional, rural setting that contains know-how accumulated over centuries. The modern sector frequently operates independently of the traditional sector. Moreover, the modern sector has traditionally been associated with technological progress while the traditional sector has been undervalued and underdeveloped.

The modern sector generally employs imported technologies that bring with them skill requirements, use of materials, organizational styles, and technical traditions that are alien to the local environment and the traditional sector. Furthermore, the technological capabilities associated with modern production are expanded primarily through new technology imports, which means that the technological traditions, developed slowly and cumulatively, become increasingly neglected and even eliminated. This has inevitably led to a reduction in the variety of indigenous technological responses. The situation described is presented graphically in figure II. Science and technology systems in developing countries are thus frequently underdeveloped. The existence of individual components, sometimes, like science and

[16] See Francisco Sagasti, "Towards endogenous science and technology for another development", *Development Dialogue*, No. 1, 1979, pp. 15-17.

[17] For a detailed discussion of the processes described, see Francisco Sagasti, *Technology Planning and Self-Reliant Development: A Latin American View* (New York, CBS International, 1979), chap. 10.

Figure II. The relations between science, technology and production in industrialized and third world countries



Source: Francisco R. Sagasti, "Towards endogenous science and technology for another development", *Development Dialogue*, No. 1, 1979, p. 16.

technology institutions, artificially created, does not constitute a system. There can be a viable system only when the components are linked through feedback effects that form closed loops for the effective exchange of experience gained, the transmission of new demands for better performance and innovation, as well as the provision of better facilities for meeting these new demands. The effective functioning of feedback loops and linkage arrangements implies the existence of a decision-making capability that can mobilize the system and harness it for the purposes of national development. This, in turn, requires the existence of political leadership convinced of the importance of the technology system. In some developing countries all the components of the technology system do not yet exist, in others the linkages are weak, ineffective and, sometimes, non-existent. Furthermore, in some countries, decision-making capabilities need to be strengthened and political leadership convinced of the role that the science and technology system can play in the attainment of development goals.

The success achieved by some developing countries in the development of their technological capacities is difficult to generalize. It is interesting to compare, for example, the "models" of, say, India and the Republic of Korea, two countries that have developed an indigenous base. The rationale of the Korean model is export orientation, foreign investment, foreign technology and foreign management know-how transfer in the first phase, leading to what might be called outward-oriented dependence. Foreign investment and control together with selective delinking take place. In the second phase, on the basis of the expertise gained during the first phase, the model becomes more international and delinking takes place. The rationale of the Indian model is to block rather than to promote the foreign ownership of productive activities and foreign control and domination of the economy. The emphasis has been on the internalization of skills and institutional structures and the acquisition of the self-confidence required to meet the nation's needs. The development of such self-confidence was a basis for the subsequent entry into the world market through nationally owned companies.[18]

There is no simple method for defining the best course of action for the development of indigenous technological capabilities. Too much emphasis, for example, on meeting the basic needs of the poor masses through small-scale village technologies may result in a nation being permanently relegated to second-class social, economic and technological status. On the other hand, over-emphasis on so-called industrializing industries combined with the aggressive acquisition of modern "high" technology may result in greater dependence at a qualitatively higher level. Clearly, there are no magic formulae or quick solutions. Rather, there is a need for a planned series of trade-offs through the introduction of a technological component in the national development strategy, and thus, for the gradual building-up of the institutions that make this approach feasible. This implies the inculcation of what might be termed a technological culture.

There will also be many problems of a more specific nature. Some of the situations that typically confront a developing country as it embarks upon the process of strengthening its technological autonomy are listed below:

(a) Many production decisions incorporate "wrong" types of products, for example, through the imitation of foreign consumption patterns;

(b) Much technology development has been left to the personal inclinations of researchers, developed during training courses frequently reflecting Western-oriented curricula and programmes;

(c) Much imported technology is not understood and there is little tradition of taking imported technology apart as a first step in its adaptation and absorption, and its subsequent substitution by local technology;

(d) There are contractual obstacles to the development of such understanding, for example, prohibitions on further use and patent systems that obstruct local adaptation;

(e) There are contractual limitations on the expansion of the use of acquired technologies, for example, export prohibition clauses;

(f) There are cases of unnecessary purchases of goods or technical processes tied to the necessary acquisition of knowledge and know-how;

(g) There is a lack of criteria for the effective selection of technology and confusion concerning the goals to be employed in evaluation such as efficiency, global output, development of initial skills, employment generation, income redistribution;

(h) The development of national technological institutions is unrelated to the development of productive units and processes;

(i) Purchasing policies in the public and private sectors are either ill-defined or non-existent;

(j) There is a lack of consultancy, extension, information and other link-up facilities.

The types of problems will obviously differ from country to country, which emphasizes the need for specificity in approaches aimed at strengthening national technological capacities.

[18] See Ashok Parthasarathi, "India's efforts to build an autonomous capacity in science and technology for development", *Development Dialogue*, No. 1, 1979, pp. 58-59.

C. Elements of technological self-reliance

The core problem of a strategy aimed at promoting technological self-reliance is twofold. It involves, on the one hand, the selection and management of foreign inputs, and on the other, the stimulation of indigenous supplies of technology. The first task requires the existence of a well-developed capacity to select and acquire technology from a variety of sources and, since none will usually have been tailored to local needs and conditions, to adapt the imported technology and its products to ensure that they can be absorbed by and can operate effectively in their new environment. The second task is to initiate an autonomous process of technological innovation and development, which requires the mobilization of the technology system.

Selection and acquisition

The technologies chosen by developing countries should obviously be appropriate, that is, they should contribute most to the economic and social objectives of development. In general, three sets of factors should be considered in determining whether a technology is appropriate, namely, development goals, resource endowments and conditions of application. Development goals can include growth of employment and output through more effective use of local resources; formation of skills; reduction in inequalities in income distribution; meeting the basic needs of the poor; improvement of the quality of life in general; and promotion of self-reliance. Resource endowments can include the availability and costs of local manpower; the level of skills and local management capabilities; availability and costs of water and energy; and natural resources. Some of these are more or less fixed while others can be influenced in the short- or long-term. The conditions of application include a number of economic and non-economic factors, such as the level of infrastructure, climate, natural environment, the social structure of the population, traditions, cultural and educational background as well as the location of industry, the size and demand of the foreign and domestic markets and the foreign exchange situation.[19] It follows that appropriate technology is not synonymous with traditional village technologies, with labour-intensive and small-scale production. Depending upon the circumstances, the most appropriate technology could be capital-intensive involving large-scale production. The appropriateness of a technology can be defined only in the economic, social and ecological context. It is meaningless to try to devise a set of appropriate technologies as such, although certain basic generalizations concerning appropriateness of sets of resource endowments and of conditions of application appear possible.

The scope for choosing a technology that is appropriate in the sense described above varies according to sectors. Agriculture, construction, and the service industries are often considered to offer more opportunities for exercising choice than some manufacturing sectors. Within the industrial sector, alternative technologies in some branches might be abundant; in other branches, especially those with sophisticated, modern technologies, they may be very limited and available only in the form of a "package". The choice of sectors depends upon a number of factors that are not influenced by the choice of technology, such as the natural resources available and the size and growth of markets, and in many cases can only be made if the sectors are described by the technology used. Once the sectors have been selected, the choice of technology can only be operationalized at the product or process level, and sometimes even at a more disaggregated level. If a product is specified in great technical detail, there may be little scope for the application of alternative technology or inputs. The choice of technology is thus not a simple choice of a capital-labour ratio or between labour- and capital-intensive production, but much more complex.

Policies aimed at promoting self-reliance in manufacturing industries should thus be based upon a systematic review of sectors and branches and an identification of product specific patterns of dependence. The forms and growth patterns, quantitative and qualitative, of technological dependence should be differentiated accordingly. Only through the application of branch and product specific criteria will a developing country be able to identify "frontier technologies" and those areas in which selective technological delinking appears possible.

Whatever choices developing countries make, they cannot afford to isolate themselves from fiercely competitive international markets nor can they cut themselves off from the mainstream of industrial and technological innovation and development. Many of the "industrializing" industries lend themselves to large-scale production and the manufacture of many products often needs to be undertaken through large-scale units based on the most modern technology. Developing countries will require a mix of technologies with different degrees of sophistication and a modern sector to increase their productivity, enhance their competitive position in international markets, and serve as an important source of technological innovation. As noted above, the problem will be of expanding the modern sector without increasing technological dependence.

[19] See "Draft report", Second Consultative Group on Appropriate Industrial Technology, Vienna, 26-30 June 1978 (ID/WG.279/12), p. 5. See also "Report of the Ministerial Level Meeting", International Forum on Appropriate Industrial Technology (ID/WG.282/123) and *Conceptual and Policy Framework for Appropriate Industrial Technology*, Monograph on Appropriate Industrial Technology No. 1 (ID/232/1).

While the technology introduced into a developing country must recognize the prevailing factor proportions, it is not necessary that it slavishly correspond to the resources available. If it were to, the mix of factors would be frozen and the deficiencies reproduced indefinitely. For instance, in China the guiding principle has been the introduction of the pioneer technology that entails the highest organic composition in as many units as possible, regardless of the fact that the shortage of capital prevents its immediate spread over the rest of the branch.[20]

Development requires both industry and agriculture. Industry normally grows faster than agriculture and the development of the agricultural sector requires an increasing number of industrial inputs. Development also requires the production of a range of consumer goods to meet the basic needs of the people and a range of capital goods, without which an economy cannot expand. There are various reasons why a country should seek to produce capital goods at an early stage in the development process. Some capital goods, for example, are required to produce industrial and agricultural consumer goods. The capacity to import, however much it can be increased, will frequently be limited in the face of increasing needs; and the developing countries cannot always import the kind of capital goods they most need—and where they can, they frequently must do so on onerous terms. The production of capital goods also promotes learning-by-doing and it is usually in the capital goods sector that innovation and technological development most rapidly gather force.

The effective selection of technology requires both information and evaluation.[21] Enterprises in developing countries, with the exception of a very few large enterprises, do not generally possess technological information, and more important, they often do not know where it can be obtained. As a result, industrial and technological decisions are taken on the basis of inadequate information. Where information does become available, the ability to evaluate such information for purposes of decision-making is often lacking.

Information centres have been established in many developing countries, in several cases with the assistance of UNIDO or UNESCO.[22] These information centres are either independent institutions or part of research institutes of other institutions. They are sometimes part of sectoral centres. The extent to which information available to all such institutions is fed into the decision-making processes varies significantly from country to country. The institutions vary in their organization and structure from a library or a mere collection of books to extension and consultancy facilities. Technological information is often a relatively undeveloped component of their activities. Processed technological information of practical value in decision-making requires trained personnel with access to information from all over the world. They will often need to be not only information specialists, but also persons with techno-economic backgrounds.

In developing countries, the evaluation of a project from an economic and technological point of view suffers not only from want of information but also from lack of capabilities and adoption of the relevant criteria.[23] Entrepreneurs make private cost-benefit analyses of their own. The banks and financial institutions also make such analyses of a project's economic viability. Several developing countries have attempted to upgrade their capabilities through institutions where evaluation is a major function. In some countries, UNIDO has assisted in establishing industrial studies, development centres or investment production centres that facilitate the building-up of evaluation capabilities. Such evaluation, however, does not always deal directly with the choice between alternative technologies. Technology is often viewed as a constant and not as a variable. Many developing countries do not appear to have made a systematic examination of the implications of the choice of technology and the criteria to be applied in such a choice.

For the acquisition of technology, the capabilities required are to specify the technological services required and to negotiate the terms and conditions. Entrepreneurs have not, with notable exceptions in the more advanced of the developing countries, significantly built up such capabilities. This compounds their weak bargaining position. Guidelines for negotiation, model contracts, and investment promotion institutions serve to assist the entrepreneurs in this regard.[24] In addition, government regulations on the import of technology help not only governmental authorities but also enterprises.

Such regulations exist, however, in only about 20 developing countries.[25] The reasons for this are

[20] See A. Emmanuel, "The multinational corporations and inequality of development", *International Social Science Journal*, vol. 28, No. 4 (1976), pp. 754-772.

[21] UNIDO has initiated several efforts designed to overcome some of the existing gaps in the area of information. Such initiatives include the Industrial and Technological Information Bank (INTIB) and various publications in the "Development and Transfer of Technology" series.

[22] For example, UNIDO has established over 40 such centres in developing countries.

[23] See *Guidelines for Project Evaluation* (United Nations publication, Sales No. E.72.II.B.) and *Guide to Practical Project Appraisal* (United Nations publication, Sales No. E.78.II.B.3.).

[24] See UNIDO, *Guidelines for Evaluation of Transfer of Technology Agreements*, Development and Transfer of Technology Series No. 12 (ID/233).

[25] The countries include the Andean Group countries, Argentina, India, Malaysia, Mexico, the Philippines, Portugal and the Republic of Korea. The nature and extent of regulations vary from country to country.

many. Some countries have not been aware of the value of regulations and others have perhaps made a conscious decision not to have such regulations at present. Among the latter category are countries that regard themselves as not having reached a stage of development at which such regulations are necessary. Yet others are faced with financial and managerial resource constraints, and they believe the climate for foreign investment would be upset by the regulations on technology imports.

Even where the capability for acquisition is built up through regulatory institutions, the direction of such regulations varies considerably. With few exceptions, government regulations were introduced only in the 1970s. Such regulations have, however, generally been concerned with limiting the size of payments and avoiding restrictive clauses. They have also helped to build up indigenous technological capabilities by not allowing restrictive clauses that might have an adverse effect on such capabilities, and, more importantly, by not allowing the import of technology when technology is indigenously available. However, monitoring and follow-up of imported technology have not yet become the strong points of the regulatory agencies. Nor do they appear to have contributed significantly to disaggregating the technology packages offered for import or developing sectorwise technology policies based on an assessment of the state of the art in the respective industrial sectors.

Adaptation

All countries import technology. Most import more than they export. An industrialized country is generally able to import the technology it requires from another industrialized country and, because it has its own technological infrastructure, to adapt it to its own requirements. As domestic infrastructure is often weak and sometimes totally lacking in developing countries, they are generally less able to adapt technology imports to their own needs.

The technologies traditionally imported by developing countries are optimally suited to the factor endowments of the rich exporting countries. Adaptation is the process of matching alien technologies to local factor endowments, social customs and values and national development objectives. It may necessitate, for example, the scaling down of the technology to the size of the local market or matching it to the local skills available which, in some cases, may require increasing the unskilled labour force. Adaptation is also the means of linking imported technology with domestic R and D.

Adaptation is therefore in that it is consonant with the strengthening of the capacity for effective acquisition and mastery of foreign technology as well as the building-up of an effective research and development system—an essential element of attempts to foster technological self-reliance.

Effective adaptation requires skilled manpower, which has had at least several years' experience in related production. This condition is not generally met in all but the more advanced developing countries. The adaptation of technology can, however, be undertaken by engineers and technicians within an enterprise, by industrial research institutes, and by consulting engineers.

Developing countries generally do not appear to have initiated incentives designed to promote adaptation. However, the environment of a protected market does not encourage the process of adaptation.

In only a few developing countries, such as Brazil, India, the Republic of Korea and Yugoslavia, have consultancy engineering capabilities been created in any significant measure. In several other countries consultancy engineering firms have come into being but their experience and versatility are limited, often confined to local consultants of equipment suppliers or other consultants from abroad.

In general, most developing countries are found to lack technological service capabilities. Such services range from macro-level industrial planning to micro-level project identification, feasibility studies, plant specifications, detailed engineering designs, civil construction and machinery installation, and the commissioning, start-up and operation of plants. The most significant gap, even in fairly industrialized developing countries, is in detailed engineering and design and in sectoral consultancy services through nationally owned units. This makes the disaggregation of imported technology packages extremely difficult and creates a critical lack of infrastructure, resulting in an undue dependence on foreign design and engineering services. This, in turn, has a negative impact on the pattern of investment for particular projects, on the requirements for capital goods and equipment, and on subsequent plant operations and management. In other developing countries, the gaps in consultancy services are even more marked and extend to almost the entire range of services indicated above.[26]

Absorption

The process of selecting and adapting technologies requires careful thought as to their subsequent absorption and diffusion, which in turn requires consideration of who is to use the technology and of the constraints on its application.

As noted in chapter one, technologies incorporate and reflect value systems and embody social and cognitive structures. They contain intrinsic

[26] "The role and functions of technology regulatory agencies in technological development" (ID/WG.272/7), p. 11.

characteristics that cannot be altered by narrowly defined processes of adaptation. Some of these characteristics (such as the degree of complexity of the technology, its scale, spatial extension, energy, material requirements, transformation, and skill, manpower and knowledge content) have the greatest possible bearing on the possibilities for diffusing and absorbing the technology.

The concept of social carriers of technology, developed by Edquist and Edqvist, is useful for identifying some of the problems associated with technology absorption.[27] They suggest that effective absorption and diffusion is dependent upon the existence of a social entity or category, a "social carrier", which has an interest in applying that technology. A social carrier could be an individual farmer who changes his pattern of production as a result of the introduction of an improved plough. The Indian "mistri" is another example of a social carrier who plays an important role in the adaptation as well as absorption and diffusion of technologies. The carrier can also be an institution. It might be, for example, an enterprise or agricultural co-operative that can develop and promote the use of new machinery and agro-technologies.

A developing country might choose to initiate a domestic network of air services using modern jet aircraft. These will need to be imported and there is nothing that can be done in the way of adaptation. The use of the aircraft is dependent upon the existence of airports and a complex system of air traffic control. A nation cannot have aircraft without a wide range of supporting and often very expensive infrastructure and services. Similarly, if a new agricultural technology is to be introduced, there must be peasants or peasant organizations that can acquire the inputs needed (seeds, implements, fertilizers, pesticides etc.), organize the labour (own or hired) and distribute the products. If these requirements cannot be met, there will be little point in attempting to introduce the technology.

A social carrier must have an objective interest in choosing and applying a specific technology. This objective interest must coincide with a subjective interest, i.e. the objective interest must be consciously felt or perceived as an adequate goal by the carrier. In order to function as a carrier, the social entity must further have some degree of social, economic or political power to be able to materialize its objective and subjective interests.

Every technology must thus have a social carrier in order to be absorbed and diffused. For a large-scale industrial technology in a developing country, the social carrier might be the government and its planning authorities, an international organization and a transnational corporation, alone or in different combinations. An agricultural technology may be "carried" by individual farmers or by the leadership of agricultural co-operatives and associations.

UNIDO has suggested that in seeking to strengthen endogenous capacities for technology adaptation and absorption, developing countries should pay particular attention to:

Industrial sectors and manufacturing processes

The assimilation of design know-how and related R and D efforts

The further development of technology and its incorporation into the production process

The development of special skills[28]

Human resource development is a particularly important aspect of technology absorption. The base for adaptation and absorption, as indeed of technological development, is provided by qualified engineers and scientists, middle-level technicians and skilled labour. As regards engineers and scientists, the situation in most developing countries is marked by both paucity in numbers and less than full utilization of their capabilities. Educational facilities for this purpose are generally lacking and the university traditions and curricula are not such as to promote their capabilities in, or association with, applied research and production activities. Several relatively small developing countries also lack the necessary scale of requirements to have fully fledged technical institutions of various types. Another phenomenon in certain developing countries is that of "brain drain" involving the export of much needed technological manpower. Generally speaking, requisite educational policies and manpower plans for projected requirements are still at an initial stage in developing countries.

As regards middle-level technicians and skilled workers, training facilities have been created in some developing countries for a variety of basic industrial skills such as fitting, turning and welding. Such capabilities can, however, thrive only where there are opportunities for application in production. Moreover, horizontal mobility of such skills within the country could substantially promote the absorption of technologies. There are no systematic data, however, which indicate that such mobility is prominent in developing countries.

The process of both adaptation and absorption would be greatly facilitated should technology contracts specify in detail the number of persons to be trained and the nature of training to be provided by the transferer of technology. The number of persons trained as part of technology contracts varies not only with the nature of technology and type of

[27] Charles Edquist and Olle Edqvist, *Social Carriers of Science and Technology for Development*, Discussion Paper 123 (Lund University, Research Policy Program, Sweden, October 1978).

[28] See "Survey on the impact of foreign technology in selected countries and priority sectors" (ID/WG.275/4/Rev.1), May 1978.

contract (including whether foreign investment is associated or not), but also with the countries of origin of the technology suppliers.

Development

The process of technological innovation is not well understood. It involves very much more than the creation of national technology centres, improved access to foreign patents and know-how or even the availability of capital to exploit them. The appropriation of knowledge appears to be the mainspring of innovation and this requires scarce resources of skill that have a high opportunity cost.

A capacity to innovate is the result of complex relationships between available capital, skills, information, communication and scientific infrastructure. It is not an autonomous process but rather a consequence of patterns of social, economic and cultural interactions. It requires, for example, high levels of co-operation between government and industry; that capacity for science and technology be linked with the productive and educational systems; integration of fiscal and trade policies; and mobilization of the creative energies and problem-solving capacities of a nation's population. It also requires the existence of social carriers that have an interest in, and possibilities for, introducing and spreading technologies thereby engendering innovation; and conscious policies designed to trace the unexploited knowledge and technologies in local communities, for example, of small farmers and women. All this implies national self-confidence and the exercise of political will. Against this background, it may prove impossible for some developing countries to embark upon their technological transformation without a corresponding and parallel social and political transformation.

One of the keys to innovation and to the mobilization of the national technology system is linkage, i.e., the creation of institutional devices that facilitate continuous intercommunication and mutual assistance between representatives of the educational system, enterprises, employers' associations, organized labour, and development agencies. The intention to communicate and co-operate must be inculcated at national, regional and local levels and permeate everyday thinking. Attitudes and motivation throughout society will determine the climate for innovation.

It is doubtful whether all countries in the third world can bring about and maintain the process of technological innovation. More than 50 developing countries, many island states among them, have very small populations. These countries lack technicians and experience. Because their markets are small, and because it is difficult to create necessary industrial complexes, they lack the capacity to produce industrial goods. The solution to such a problem is generally assumed to lie in specialization through international trade and the promotion of regional co-operation to enhance collective self-reliance. However, free trade does not always work to the advantage of small developing countries. Moreover, it implies a commitment to levels of co-operation never achieved by the industrialized countries.

Technology development calls for well-directed programmes designed to promote research activity. At present, in only a few developing countries do industrial establishments have research and development units of their own, and even these have a limited record and with very little horizontal transfer. In general, whatever research takes place in developing countries is by and large government funded through industrial research institutes or universities. This expenditure, which does not exceed 0.4 per cent of the gross national product (GNP) of the developing countries, is often spent on basic rather than applied research, involving programmes not necessarily drawn up as a result of clearly defined industry-related priorities. In some developing countries, voluntary agencies and institutions are attempting to promote appropriate technology in one or more specific sectors. But they tend to be small, lacking in government support and isolated from the mainstream of industrial activities. They have thus not generally been able to make any significant impact on the technological development of the countries concerned. The number of developing countries that have activities for invention promotion or patent registration is also small, thus hardly providing any impetus to the innovative capabilities of the local population. The approach to industrial research is itself generally more Western-oriented than inward looking, contributing very little to the technological advancement of locally used technologies and to the solution of the problems of the rural areas.

Manpower and financial constraints affect the process of technological innovation and development in a large number of other, more detailed, ways. The commercialization of research findings, for example, is dependent upon the existence of such services as product and process development, pilot plant, plant design and installation, process adjustment, advice on manufacturing operations, quality control, product and process improvement. With a few exceptions, such skills and services are lacking in developing countries. The number of processes commercialized by industrial research institutes in developing countries is not significant. Except for the least developed countries, most developing countries have one, and often more, research institutes. Some countries even appear to have too many research institutes to function in an effective and co-ordinated manner. The research institutes established have been of various types but, by and large, they belong to the categories of government controlled, autonomous, state-aided or quasi-governmental institutes. There are both single purpose and multi-purpose institutes and

single sector and multi-sector ones. At one end of the spectrum are institutes providing quality control and testing services in a single sector of industry and, at the other end, are multi-sector institutes with services extending to applied research, pilot plants and extension and consultancy.

The limitations of such institutes in developing countries have been well documented.[29] Principal among the causes of their ineffectiveness appear to be:

(a) A structure that is too ambitious, and executive officers with inadequate training and experience;

(b) Failure to assess the applied research and development needs of the nation and industry prior to formulating programmes, building infrastructure and equipping laboratories;

(c) Operational shortcomings, including inept management, wrong type of staff, poor staff remuneration, and lack of business orientation, staff mobility, priority-based research, commercialization efforts, package of services to industry, guarantees for technology development, and motivation to undertake contract research;

(d) Weak contacts and co-ordination with industry and government, lack of adequate funding and the indiscriminate importation of technology.

Even if these constraints were removed, some of the more general problems involved in encouraging the process of technological innovation and technology development, those rooted in social and economic structures, might still remain. Improvements in organizational design, for example, provide no guarantees that technological development will be transmitted to rural areas, to the vast majority of the population or lead to an improvement in the general level of technological awareness and capability of the population (as distinct from a number of scientists and engineers). These and similar problems have yet to be adequately considered by either the developing countries or international bodies.

D. Technology policy and technology planning

The above considerations indicate that while developing countries are becoming increasingly aware of the challenge of developing technological capabilities, their responses have varied. The elements of such capabilities and the factors that influence them are so numerous and varied that policies and actions have generally been compartmentalized and uncoordinated. Adequate methodologies for the formulation of technology policies and plans have yet to emerge.

Technology policies and plans, however, are a matter of high priority. It will no doubt prove impossible to promote technological self-reliance without recourse to planning and the preparation of policies that are linked to strategies of national development. Indeed, given the pervasive influence of technology and its motive force planning in the area of technology may, in many cases, prove more important than planning for investment.

Technology policy is not synonymous with technology planning but is a basic function of government aimed at creating a framework in which decisions concerning technological choice can be made and implemented. Technology planning implies the existence of a formally constituted and internally consistent set of goals, objectives and instruments. Whereas all developing countries should seek to formulate technology policy within which basic choices can be made, the preparation of comprehensive technology plans may be both beyond the scope of, and unnecessary for, countries with limited regulatory and supervisory capabilities and where institutional continuity is a problem. Past experience with both technology policy formulation and technology planning show that the state of the art is at a rather elementary stage.

For the majority of developing countries, the need to develop a technology planning capability will no doubt become increasingly urgent but experience has so far been disappointing. It was only in the early 1970s that such countries as Argentina, Brazil, India, Mexico, the Philippines, the Republic of Korea and those of the Andean Group set out to control technology imports.

In the mid 1970s, the first technology plans, prepared by Brazil, India, Mexico, Pakistan and Venezuela, appeared. The importance afforded technology by the developing countries is evidenced by the fact that by 1977 the number of countries exercising governmental control of technology imports had, according to UNIDO estimates, increased to approximately 30.

As suggested earlier, the experience gained so far indicates that while regulations and programmes have helped to build up technology institutions and to strengthen the bargaining position of the developing countries as technology importers, they have gone little further than the review and approval of technology supply arrangements at the enterprise level, and that the linkages between technology imports and the promotion of national capabilities are generally ineffective. Problems associated with technology absorption and adaptation have so far generally received little attention. Even where technology plans have been prepared, the relationship

[29] See, for example, ESCAP, *Guidelines for Development of Industrial Technology in Asia and the Pacific* (Bangkok, 1976), chap. IV and V. See also "Joint UNDP/UNIDO evaluation of industrial research and service institutes; Addendum 1" (ID/B/C.3/86/Add.1).

between these plans and national development strategies is weak.[30]

In discussing technology planning, it must be acknowledged that there has been, in many respects, a growing disenchantment with the idea of comprehensive planning as advocated and described in traditional textbooks. Indeed, the truth is that few people today have the same sort of blind faith in planning that was prevalent at the end of the 1950s and the beginning of the 1960s. Even in centrally planned economies, such as China and the Union of Soviet Socialist Republics, attempts are being made to correct apparent rigidities in planning and to increasingly liberalize the operation of the economy. In non-centrally planned economies there are only a handful of countries that have medium-term plans that play a role in the process of allocation of resources. The trend of de-emphasizing the importance of comprehensive plans has continued because of the many difficulties encountered, not so much in the formulation phase of such plans, but rather in their implementation. Discrepancies between planned and actual figures are all too common. Planning is difficult because, in spite of the calls for increased self-reliance, the economies of most countries have become more instead of less open to the world economy. Also, there have been considerable increases in the flow of financial resources, as shown by the growth of the external debt of developing countries, and payments for the transfer of technology account for an ever-expanding portion of trade in services. Further, sudden fluctuations in the prices of basic inputs and commodities have meant the transfer of inflationary pressures from one country to another.

In setting out to plan its technological future, a nation is seeking to control and manage something that is pervasive and that does not recognize sectoral distinctions and ministerial responsibilities. Of all the things that man might set out to plan, technology is undoubtedly one of the most elusive and difficult. Nowhere has a nation yet demonstrated a real capacity to control its technological future. Even in the motherland of planning, the Union of Soviet Socialist Republics, the Director of the Institute of Economics of the Academy of Science has been quoted as saying that "the planning of scientific and technical progress . . . is the weakest link in the whole complex of economic planning and in the whole system of national incentives for production".[31]

Yet without technology planning a country will find it difficult to decide whether the technological inputs into national development efforts ought to be imported or obtained from domestic sources. Also, it will not be possible to ensure that the technological inputs are appropriate from the viewpoints of resource use, employment creation, income redistribution, needs satisfaction and environmental effects. In general, systematic progress towards the strengthening of endogenous capabilities and the substitution of appropriate domestic technologies for imported ones will be impossible without the existence of a broadly planned framework over a long period within which individual development projects can be fitted.

In formulating a technology plan, developing countries should seek to create a framework for effective interaction between government, private enterprise and institutions for science and technology. They will need to give careful consideration to such matters as the needs, resources and socio-economic objectives of the country; the promotion of a social climate that encourages the application of technology in different sectors and at different levels; the formulation of measures designed to stimulate local technological capabilities; the setting-up of machinery for the selection and assessment of technologies and techniques; the selective import of know-how and its adaptation to local requirements; the development of technology packages involving frontier technologies and sets of technologies; and the development of manpower for the management of technology. Above all, the environment created should, at one level, inspire the confidence of industry and research, of engineers, technologists and scientists and, at another, seek to mobilize the creative problem-solving capacities of ordinary people at the local level.

The effective exercise of a technology function and of a technology planning capability implies the existence of scientific and technological intelligence, or the capacity to appropriate and utilize knowledge. Technological intelligence is an essential component of an anticipatory intelligence, or the capacity of a nation to identify its relevant strengths and weaknesses, to understand and analyse threats and opportunities of different kinds and to translate the resulting knowledge into policy and action. It is doubtful whether any of the world's nations, developed or developing, have yet developed a real social intelligence, although several countries, notably Japan, have demonstrated a technology intelligence capability.

E. Constraints on technological self-reliance at the international level

It has been stressed that the technological dependence of the third world is but one aspect, though a crucial one, of the general pattern of dependence into which the third world is locked. It is the institutions and mechnisms that underlie the functioning of the international economic system

[30] See, for example, "Technology planning in developing countries" (TD/238/Supp. 1), May 1979.

[31] B. Williams, *Technology Investment and Growth* (London, Chapman and Hall, 1967), p. 149.

that generate dependence. Many of the system's mechanisms are not the result of conscious design. They work automatically, but once in operation they persistently aggravate the fundamental inequalities between rich and poor nations.

The international economic system is a complex mixture of dynamic forces, of active and potential conflict. It is characterized by unequal specialization and exchange reflected in an inequitable international division of labour. The system, with its tendencies towards the internationalization of capital and the transnationalization of production, has inherent forces that tend towards the marginalization and fragmentation of the developing countries. Within this system, modern science and technology are becoming ever more hierarchical, centralized and specialization oriented. Scientific innovation and technology development are dominated by transnational structures, military industrial complexes, a near global network of agro-business, and a network of universities and research institutions, all of which are highly interpenetrated and mutually reinforcing.

Against this background, strategies designed to enhance national self-reliance are imperative. It must be questioned, however, whether they are really feasible for all but a handful of developing countries. Such strategies inevitably impinge on the profits and perceived interests of the rich nations and are thus unlikely to receive their support. Radical circles have warned that self-reliance will only have real meaning for the developing countries when they have freed themselves from the system that maintains their underdevelopment.[32]

Even if possible for some developing countries, technological self-reliance may prove beyond the reach of many small and economically and politically vulnerable developing countries. This questions the validity of theory, especially classical economic theory: whether, for example, the technological transformation of the third world based upon strategies of national and collective self-reliance is wholly compatible with the attainment of an international division of labour based upon industrial and agricultural comparative advantage.

F. Constraints on technological self-reliance at the national level

The concept of technological self-reliance is, like other concepts before it, in danger of becoming co-opted by vested interests within the existing international order. Some of the arguments underlying self-reliance tend to become distorted and used to reinforce the power of entrenched interests in the developing countries. Some élites in developing countries have a tendency to use such arguments to increase their independence from rich country interests without demonstrating a readiness to share any of the advantages that might result from increased self-reliance.

So far only a handful of countries have been able to incorporate in a meaningful way the concept of self-reliance in their national development strategies. Not many countries have found it easy, or an absolute necessity, to disentangle themselves from the complex webs of commercial, financial and technological relations that link them to the outside world in a sort of "external-reliance" and that, in many cases, maintain and feed their dependence.

Movements to organize labour, to mobilize peasants and to create conditions at the local level conducive to increased self-reliance are sometimes systematically suppressed in developing countries. In such situations it is difficult to see how a redistribution of Western science and technology and the strengthening of domestic technological capabilities would serve to improve the conditions of the poor and under-privileged masses. A central question, already raised in this paper, is whether it is possible for all developing countries to embark upon their technological transformation without a corresponding and parallel social and political transformation. This raises questions concerning the conditions required for, and the nature of the social transformation most conducive to, self-reliant development and selective technological delinking.

Even where favourable conditions exist, it is questionable whether something as pervasive as technology can be planned and whether nations can choose their technological future. Planning requires consensus on the goals and objectives of development, a commodity frequently in very short supply. And without clarity on the nature of the internal development to be pursued, it will be difficult to answer questions concerning technology development and innovation.

When the conditions are right, a good deal may be achieved in technology planning in a comparatively short period. Many developing countries are already involved in the process of strengtnening their science and technology institutions and there is evidence that many developing countries may be able to increase their self-reliance in a wide range of consumer and capital good industries in the near future.

This will be an important start. However, self-reliance, if it is to have real meaning, must be defined to include more than the production of goods and services and more than the building-up of science and technology institutions. It must ultimately be seen as a strategy that builds development around individuals and groups through the mobilization and deployment of local resources, material and non-material, and indigenous effort. In this sense,

[32] See, for example, Samir Amin, "Self-reliance and the new international order", *Monthly Review*, July-August 1977; and Harry Magdoff, "The limits of international reform", *Monthly Review*, May 1978.

self-reliance transcends the application of techniques. Rather, it contributes directly to the formation of new value systems and to a direct attack on poverty, alienation and frustration as well as to the more creative utilization of productive factors. Self-reliant development, with its emphasis on local rather than imported institutions and technologies, is thus a means whereby a nation can reduce its vulnerability to events and decisions that fall outside its control.

All developing nations should be able to strengthen their technological capabilities, especially their capacities to control the inflow of foreign technology. Not all developing countries may be able to do so, however, within the framework of meaningful strategies of national self-reliance, with their emphasis on the mobilization of indigenous resources and knowledge.

It follows that a diversity of starting points necessarily implies a diversity of responses. In fashioning their strategies for national self-reliance, developing countries will no doubt experience a greater need for the systematic exchange of relevant information and experience than for a generalized, universally valid approach.

III. Towards operational strategies

A. Objectives of technology policy

Technology policy can only be formulated on the basis of clearly defined development goals and objectives and in terms of decisions concerning the type and volume of goods and services that need to be produced and the resources to be mobilized and deployed. In this context, the production of the "right" goods with the "wrong" technology could in some respects be considered preferable to the production of the "wrong" goods with the "right" technology.

The technology policies of the developing countries are likely to be guided by a common goal, namely, the desire to exercise greater control over their social, economic and industrial development through the promotion of technological self-reliance, a precondition for meeting the basic material needs of their poor and under-privileged masses. Policies should address the problem of controlling and managing foreign technology inputs on the one hand and of stimulating the development of indigenous supplies of technology on the other. This implies the effective integration of two main streams: the "flow stream", with its emphasis on the selection and acquisition of foreign technology and its subsequent adaptation, absorption and diffusion; and the "stock stream", with its emphasis on the development of endogenous technological strengths and the promotion of the capacity to innovate.

The emphasis in the past has been firmly on questions relating to the transfer or flow of technology, the development of stocks having received only scant attention. It will be the task of technology policy to harmonize flows and stocks. Attempts at harmonization will need to recognize, however, that the two streams are not independent or mutually exclusive, but rather interactive at different levels. It may also be necessary to tackle the problems associated with each stream within different time-frames. The development of the capacity to control foreign technology inflow might be afforded short-term importance. Without such a capacity, policies aimed at fostering endogenous technology development and the capacity to innovate are likely to be continuously undermined.

The exercise of a national technology function obviously requires that the national science and technology system must function properly. However, these systems are, for a variety of reasons, frequently underdeveloped in developing countries. Typically, technological capacities are not strongly linked to industrial production, and the modern sector, usually export-oriented, frequently operates independently of the traditional sector. It will be one of the key tasks of policy to come to terms with these problems: to link the conduct of technological activities and the development of technologies with the growth of production; and to systematically and selectively recover the traditional technological base, weaving modern methods into the traditional tapestry of a developing society. If this is achieved, the technology system will be better able to react to stimulation and a revision of inputs within realistic periods.

Experience gained in developing countries indicates that these and similar problems can best be tackled when science and technology policies are formulated and implemented separately. These cannot be categorically differentiated with any clarity since they overlap to a great extent,[33] yet there is a difference in emphasis, which is of great importance to developing societies. Science is essentially attitudinal and science policy has the objective of encouraging the acquisition of scientific and technological understanding that may, or may not, be of use in the development of knowledge directly applicable to the pursuit of economic and social goals. The objective of technology policy, on the other hand, is to stimulate the generation of the scientific and technological knowledge to be applied in the solution of well-defined problems in certain areas of production and in social welfare. Although both science and technology policies are concerned with the generation of scientific and technological knowledge, there is a basic difference in that with technology policy the knowledge concerned is organized, promoted, financed etc. by policy-making institutions with the explicit purpose of using it to serve specific social and economic needs. In other words, technology policy is defined by objectives external to the scientific world as such. Technology policy is oriented towards the finding of acceptable solutions within a given social context and time-frame; since its objectives are essentially production and social welfare and it is not developed in the abstract, it is subject to decisions of a scope much wider than merely solving technical problems.

[33] See Junta de Acuerdo de Cartagena, *Technology Policy and Economic Development* (Ottawa, IDRC, 1975), pp. 7-8.

Moreover, as is well known, scientific knowledge usually flows freely without significant constraints whereas technological know-how is a commodity that is traded on the world market and is vigorously protected.

Separate, but interlinked, policies for science and technology should make it possible to deal more effectively with technology problems and problems with the development of indigenous technological capabilities.

B. A framework for national action

A framework for national action in technology consists of four interrelated steps:

"(a) A broad consensus on the desired mix of appropriate technology and the pattern of national technological capabilities;

"(b) An assessment of the present status of technological capabilities and identification of gaps and shortcomings;

"(c) Strategy formulation in terms of policies, programmes and institutions, together with the financial and manpower resources needed for its implementation;

"(d) A re-assessment of the coherence of ends and means as well as arrangements for co-ordination and monitoring."[34]

The purpose of the framework given below is not to present a step-by-step approach to the formulation of policy but to list what might be termed indicative issues. Its purpose is to foster the awareness that technology is a resource and that there is a continuous need for clarity in the relationship between ends and means in technology policy.

The framework is based upon the three essential pillars of policies, programmes and institutions. Policies by themselves can only act like levers or valves that can be used to channel or to cut off the flow of national resources or energies. The specific orientation of resources and energies is conditioned by programmes of action. Institutions are the instruments that formulate and implement policies and programmes. Excessive reliance on any one of these three pillars at the expense of the other two should be avoided.

Technology mix

The first step toward an effective technology policy requires a broad agreement on the mix of appropriate technology and then on the pattern of national technological capabilities. Though in a general sense technological capabilities will be required whatever the technology mix, clarity is essential for the generation of particular types of capabilities. The latter will in turn be derived from national development objectives. If the benefits of technology are to be spread throughout the population, then its application and the capabilities required should cover a very wide field of national activity. Hence, it can be said for all developing countries that the basic common skills should be generated abundantly and existing technological skills should be upgraded rather than uprooted. Subject to this, the technology mix, and therefore the desired pattern of technological capabilities, may vary for each country. In a labour surplus economy the emphasis may be on labour-intensive industries while in developing countries with a shortage of manpower, labour-saving technologies and skills to operate sophisticated machines may require special attention. In the case of export-led growth, the technological capabilities of the export industry sector should receive priority. Wherever possible, the desired levels of particular technological skills should be quantified. Broad norms should be adopted bearing in mind that technological skills should be created as an infrastructure ahead of demand rather than as a response to demands as they merge at a particular time.

The selection of the most appropriate technological mix requires the identification of technological needs at both the macro level, in terms of sectoral priorities and the technological inputs for each priority and critical manufacturing sector, and the micro level of individual industrial enterprises. At the macro level, sectoral priorities can normally be identified through national plans and growth strategies. At the technological level, such priorities have to be broken down in terms of requirements of process or production know-how, the supply of technical inputs, provision for technological services, specialized manpower training for management and plant operations and the like. These, in turn, are determinants of, and closely dependent on, the choice of technology from among the various alternatives that may be available. At the micro level, principal technological needs include improvement of productivity, quality control and institutional technical support to industry, including information linkages, which have to be tackled on a national or even regional basis but which relate primarily to the working of individual enterprises.

Sector technological demand should also be identified at the regional level in the case of developing countries. Several regions, particularly in Latin America and in parts of Africa, lend themselves to an effective regional approach to several priority industrial sectors such as fertilizers, petrochemicals and capital goods production. Such identification

[34] See, in this connection, "Strengthening the technological capabilities of developing countries: a framework for national action" (A/CONF.81/BP/UNIDO), pp. 19 and 20.

could be a prerequisite for strengthening the bargaining position of regional industrial units in respect of technology acquisition and the development of regional technological capability.

Assessment of the present situation

An assessment of the present status of technological capabilities and of the effectiveness of national technology systems, aimed at identifying gaps, limitations and deficiencies, has not yet been carried out by many developing countries. It is, however, a prerequisite for the proper formulation of a strategy.

Reviews of existing situations are notoriously static undertakings. It is essential that an assessment of technological capabilities take place in a dynamic and development oriented framework, being cognizant of global and regional technological trends and developments on the one hand and national development aims and ambitions on the other.

An assessment of technological capabilities may include the items listed below.

Technological manpower

The strength of the existing technical and scientific manpower should be evaluated quantitatively and qualitatively, as should likely developments in patterns of deployment and utilization. The extent of brain drain, if any, may need to be assessed. The evaluation of manpower resources should be undertaken keeping reallocation possibilities in mind, since additions to manpower may require from three to five years, short of reversing the brain drain or of bringing in expatriate manpower. The categories of manpower to be assessed include scientists, science graduates, research and development personnel, teachers and engineers (civil, mechanical, electrical, chemical, metallurgical, electronic etc.) who are engaged in production, teaching, consultancy, design and other occupations; middle-level technicians of various types; trained artisans; traditional artisans etc.

Indigenous technologies

Many developing countries have yet to obtain a clear picture of the traditional technologies available to them. Such technologies, developed over centuries and representing accumulated experience, are likely to be appropriate to local conditions and particularly relevant to the problems of rural areas and to the development in these areas of such activities as agro-processing and building materials and construction. The inventory and evaluation of indigenous technologies should take place with a view to identifying the possibilities for their systematic upgrading and improvement through the application of modern science and technology. Research and development institutes in developing countries have an important role to play in the assessment of indigenous technologies.

Sectoral developments

An assessment of the status of technological advance and manpower in specific sectors will need to be made. The sectors should include not only individual industrial sectors, but also technological service capability areas such as consultancy, design and construction. High priority industrial sectors are likely to include food processing and engineering industries as well as the industrializing industries, which allow for the optimal utilization of local natural resources and for the longer-term accumulation of technological capabilities. The assessment of sectoral developments should cover not only large-scale industrial units and technologies, but also small-scale and traditional technologies.

Impact of policy

The effective exercise of a technology function requires a careful assessment of the scope for implementing policy and for government intervention and regulation in the technology market. In making such an assessment, it must be recognized that there is a range of contextual considerations involving social, political and economic structures that constrain policy formulation and implementation and that policies can have an indirect as well as a direct effect on the development of technological capabilities. The technology system operates within the frame of an intellectual climate, a system of values, attitudes and modes of behaviour as well as of current legislation. The direct impact of this on strategies, policies and plans and on the definition of the composition of social demand may be obvious, although difficult to generalize. Less obvious is the indirect impact on the components of the science and technology system of policies governing such areas as taxation laws, import controls, customs duties, the influx of foreign capital and labour. All these will have a profound effect on the operation of the technology system and together constitute what might be termed an implicit science and technology policy.[35] In many areas, implicit technological policies are able to run directly against the explicit technological policies contained in science and technology plans. It is this contradiction that

[35] The International Development Research Centre's project on science and technology policy instruments provides ample and interesting examples of "implicit" science and technology policies from several countries in Latin America, the Middle East, southern Europe and Asia. See Francisco Sagasti, *Science and Technology for Development: Main Comparative Report of the Science and Technology Policy Instruments Projects* (Ottawa, IDRC, 1979).

frequently lies behind failures in policy implementation.

Another area requiring careful investigation is the identification of relevant instruments for influencing the patterns of demand for technology. In the past, emphasis has been clearly placed on the supply side with an implicit belief that demand would be generated almost automatically. In reviewing possibilities for influencing technology demand, attention should be given to such instruments as industrial programming and priority-setting, industrial financing and state purchasing arrangements.

Internal diffusion of technology

The state of diffusion of technology within the country and the existence of conditions to promote such diffusion should be assessed. Internal mobility of technical personnel promotes transfer and diffusion and enables the training and transfer of skills to a much larger number of persons than would otherwise be possible. The economic relationships between the urban and rural areas have to be examined to see how their strengthening could contribute to the growth of technological skills in the rural areas. The facilities and instruments available for the promotion of innovation should also be examined.

Technological institutions

An assessment of the capacities of existing institutional infrastructure is essential. This should identify the function performed by institutions, the means at their disposal and their potential for change and development. Technological institutions cannot be construed in the narrow sense of industrial research organizations and the like. The assessment should also cover such institutions as information centres, project formulation and evaluation centres, investment promotion agencies, investment boards, technology regulating agencies, productivity councils, design institutions, consultancy and other technological service agencies, extension centres for small industries, institutions for technological education and research institutes. In other words, the review should include promotional, regulatory and service institutions since their activities will involve implicit policy and impinge in a variety of ways on the process of technological development. In this sense, it may be more appropriate to think in terms of functions and services to be performed rather than in terms of institutions *per se*, since, ultimately, it is there that the major interest lies. This approach requires the specification of such functions and services and its correlation with the potential offered by available institutions.

In assessing existing institutional capabilities, it is essential to go beyond "numbers" (of technical personnel, expenditure incurred and so on) to a qualitative evaluation of the output of the institutions. The possibilities of strengthening the institutions, extending the scope of their activities to include more functions and services, avoiding duplication in their work and ensuring co-ordination should be identified. The place of the respective institutions in the government hierarchy, their involvement in decision-making for industrial and technological development, and the contacts they have with industry and the public are critical factors in assessing their effectiveness. With respect to research institutes, their role in essential technological functions such as extension, pilot plant and commercialization of technologies should also be assessed.

Summary

The above assessment should provide the following: *(a)* sufficient information and insights to understand ongoing processes at different levels and to identify future possibilities; *(b)* an understanding of the scope for technology policy and the possibilities for government intervention and regulation in the development of technological capabilities; *(c)* the possibility of identifying sector and branch specific patterns of dependence, sector and branch priorities and important intersectoral relationships with significant linkages and backward and forward multiplier effects; *(d)* an understanding of available and needed institutional infrastructure and manpower requirements; *(e)* an extensive basis for identifying priorities in a range of interrelated areas and of evaluating the advantages and disadvantages associated with technology alternatives at different levels; and *(f)* the linking of technology policy with national economic, social and industrial development objectives.

Policies and policy instruments

The practical formulation of the strategy in terms of policies, programmes and institutions will vary from country to country in accordance with conditions, requirements and priorities. While specific actions are suggested illustratively in what follows, the emphasis is on providing a framework for action.

Developing countries are able to apply a large number of policy instruments in seeking to attain their technological objectives and to achieve the technology mix deemed most desirable. The effective application of such instruments, however, will require the identification of the structural forces and deficiencies that are likely to invalidate their utilization. One of the themes of this report is that contextual factors may be equally or even more important than individual policy instruments in determining the success of technology policy-making.

Policy instruments can take various forms and be of the explicit or implicit type. They include national laws and regulations for licensing of production capacity of industrial enterprises (as in India) or the defining of new and necessary industries (as in Mexico), controls over majority foreign equity holdings, employment of expatriates, controls over imports, incentives for exports and import substitution, regulatory control over foreign technology, regulations for use of domestic consultancy agencies and technical services, various forms of financial assistance and incentives for small-scale and rural industries and the like. In most developing countries, several fiscal and regulatory instruments are utilized in combination with one another. A number of governmental and semi-governmental agencies are consequently involved in dealing with one or another policy instrument. One of the criticisms often levelled is the multiplicity of governmental regulations and agencies with which domestic industry has to deal. While adequate co-ordination is undoubtedly necessary and bureaucratic delays need to be minimized, the complex and manifold issues of industrial and technological growth in most developing countries necessitate that governmental agencies play a critical and determinant role in several policy areas. The nature and extent of such a role obviously depends on the circumstances and objectives of each developing country but the nature and magnitude of the problems are such that the free play of market forces may only accentuate existing gaps and problem areas.

As noted above, policies and instruments relating directly to technology have to be viewed within the framework of overall economic and industrial policies. By and large, however, such policies and mechanisms need to be defined in respect of *(a)* the role of private foreign investment, both existing and new; *(b)* fields in which foreign technology is considered particularly necessary, including measures designed to ensure adequate flows, such as tax benefits; *(c)* production and service sectors in which foreign technology should not be encouraged, including technical and management services, merchandising, and internal sales and sectors where domestic capability is either adequate or should be developed; *(d)* the establishment and development of a regulatory mechanism to regulate such inflow in accordance with prescribed and well-defined guidelines; *(e)* incentives and measures to encourage domestic technological growth, including tax rebates for R and D expenditure, limited duration of foreign technology agreements etc.; *(f)* incentives and measures to promote domestic technological services, particularly consultancy and engineering services, including tax relief and regulatory action such as insistence on local consultancy agencies being appointed as prime consultants in selected fields; and *(g)* financial assistance and support to domestic technology agencies. Such a list of policy measures and instruments relating directly to technology can only be illustrative and not exhaustive and must be formulated in the context of each country or region.

General policy guidelines

In every developing country, technology policy will need to take into consideration selective action. As noted above, the definition of the technology mix that is socially optimized requires the systematic identification of sector- and product-specific alternatives and the careful analysis of the various constraints associated with each of the options. Despite the enormous differences among developing countries, five general guidelines appear to possess a particular relevance in the identification of the most appropriate technology mix:

Effective control of key sectors. Without this there will be little progress in the direction of autonomous decision-making and little influence over the process of accumulation let alone development. Such control is a precondition for the establishment of dynamic inter-industry linkages. It involves control of the market, of essential inputs, of forward and backward linkages as well as of research and development of technologies. The control of key sectors may call for policies of selective nationalization. Such policies should recognize, however, that ownership should not be confused with control and that it is control that counts.

Converging needs with effective demand. In many developing countries, the gap between the needs of society, or more specifically, the needs of the underprivileged majority, and effective demand, i.e., the demand that can enter monetary exchange relations, is dramatically increasing. Decreasing fulfilment of basic needs and overconsumption in some urban growth poles are the familiar symptoms of this trend. A conscious policy to reconcile needs with effective demand thus becomes of utmost importance. This implies three interrelated priority activities: the identification of social needs; the definition of criteria for the adjustment of effective demand to social needs (such as maximizing the basic needs satisfaction of the poor, the productive integration of the labour force, the use of local natural resources and the use of local scientific, technological capabilities and traditional skills); and restructuring the supply side and solving the problem of the choice of product.

Support for agriculture. Especially important is the promotion of self-sufficiency in basic foodstuffs. Support for agriculture, which would help guarantee self-sufficiency in food, is one of the main priorities for development strategies and especially for industrialization strategies. This applies to sectors producing agricultural inputs (implements, fertilizers, pesticides, irrigation equipment etc.), to sectors

serving transport and distribution requirements, and to those processing agricultural goods. Possibilities for the application of science and technology to increase agricultural productivity, improve post-harvest technology, and introduce innovations into plantation industries, fisheries and forestry are considerable.

Social optimization of using and processing resources, including energy resources. Some developing countries still have to develop the preconditions for effective control over the natural resources located within their frontiers, i.e. national capacities to detect, exploit and process such resources. Thus, the utmost importance should be given to activities in this field, which should include a systematic search for areas in which co-operation between developing countries appears feasible. Availability of natural and energy resources should have a determining effect on the contents of industrialization strategy as regards choice of sectors, choice of process and techniques.

The identification and strengthening of industrializing industries. Priority should be given to the identification and promotion of the so-called industrializing industries, i.e. industries that allow for the optimal use of local natural resources, guarantee the fulfilment of basic needs and allow for the long-term optimization of accumulation and scientific-technological capacities. Such a strategy includes, among other things, the development of the engineering machine tool industry, the production of textile and agricultural machinery, and a reorientation of basic industries, processing locally available resources that aim to increase the share of down-stream activities and to foster the integration of the country's industrial and agricultural production. This strategy should include attempts to strengthen local engineering capacities, especially with regard to pre-investment studies, chemical engineering and equipment design and attempts to control technological building blocks and technology life-cycles.

The development of industrializing industries should be related to the growth and development of physical infrastructure, another prerequisite for the process of industrial development. The planning and provision of such physical infrastructure as electric power, transport and communication systems, including railways, roads and shipping, should ensure that such facilities would effectively meet the projected needs of at least those industries that form the spearhead of industrialization efforts.

Acceptance of the general guidelines outlined above may well call for the transformation of the productive system. The transformation suggested would involve the reorientation of production away from mimetic patterns of consumption that favour a diversity of goods for higher-income groups, to a productive structure based on the satisfaction of basic needs and with greater emphasis on collective rather than individual consumption. This revised pattern could substantially reduce the need for imported technologies and lead to an increased demand for local scientific and technological activities. The selection of the most appropriate policy instruments for promoting the development of indigenous technological capabilities will need to take account of the above guidelines.

Levels

Technology policy should address problems and outline options at different levels. National strategies for technological development should be based upon the recognition that the international technology situation and the international division of labour are not static but dynamic. National strategies should thus reflect an appreciation of global and regional trends and developments, a consideration that will become increasingly important as efforts in the direction of collective self-reliance and Technical Co-operation among Developing Countries (TCDC) and Economic Co-operation among Developing Countries (ECDC) are intensified.

As noted above, an essential ingredient of technology policy is decisions concerning sector and branch specific product and process technologies. Such decisions can be articulated only at the enterprise level. The enterprise level is thus of critical importance. Technology choices at this level, however, cannot be left to the discretion of individual entrepreneurs and to market mechanisms. The interest of the nation will not necessarily be compatible with that of an individual or of groups of entrepreneurs. Individual enterprises may well be motivated by profit rather than social welfare considerations. Profit maximization may well encourage them to import foreign technologies under conditions that perpetuate national technological dependence. One of the essential functions of technology policy is thus to guide the actions of entrepreneurs in socially desirable directions. In most cases this will necessitate a system of incentives as well as of regulation and control.

Policies for selected areas

In chapter II, technological self-reliance was defined in terms of the capacity to select, acquire, adapt and absorb foreign technology inputs (regulating the flow stream) and of developing an indigenous base and the capacity to innovate (the development of stocks). We now consider some of the policy options under each of these main headings.

Selection and acquisition of technologies

As regards the technology mix, developing countries appear to have a special need for technologies that meet the following criteria:

"(a) High employment potential, including indirect employment through backward linkages with national suppliers and forward linkages with national processors, distributors and users;

"(b) High productivity per unit of capital and other scarce resources;

"(c) Higher labour productivity in the context of increased employment, that is, the maximization of the productivity of labour in the economy as a whole;

"(d) The utilization of domestic materials, especially of raw materials previously considered of little value;

"(e) A scale of production that is suitable for the local markets to be served (unless exports are involved), with special consideration being given to small, fragmented markets in rural areas;

"(f) Low running costs and cheap and easy maintenance;

"(g) Maximum opportunity for the development, as well as use, of national skills and national management experience;

"(h) Dynamic opportunities for the further improvement of technologies and feedback effect on the national capacity to develop new technologies."[36]

Instruments that can be employed by developing countries to promote the selection of appropriate technology could include, for example:

"(a) Differential direct and indirect taxation (e.g. tax exemption or lower taxation for products/enterprises in the small-scale sector or utilizing newly developed or indigenous technologies);

"(b) Differential financial and credit policies (e.g. lower rates of interest and liberal credit for products/enterprises in the small-scale sector or utilizing newly developed or indigenous technologies);

"(c) Industrial policies concerning size of units of criteria for expansion (e.g. certain products could be reserved for manufacture in the small-scale sector; policies discouraging more assembly industries based on imported components);

"(d) Trade policies on import of capital goods or raw materials (e.g. import control; not permitting import of equipment of too large a capacity; phased programmes for the reduction of import content of raw materials and components);

"(e) Policies on foreign investment and import of technology (e.g. discouraging turnkey contracts; not allowing foreign investment or import of technology in specified areas; associating local consultants or research and development institutions in selection)."[37]

Policies aimed at regulating the acquisition of foreign technology should not only cover technology *per se*, but also equipment (which embodies technology) and foreign investment (which is a vehicle of technology and invariably predetermines it). A mechanism for screening technology contracts will be necessary. Such screening could ensure that the technological services required are clearly specified; technology packages are "unpackaged" wherever possible to admit contributions from indigenous technological capabilities; adequate provision should be made for the training of local technicians; there should be no unwarranted restrictions on the further dissemination of the technologies and the technological capabilities involved. Although each developing country may have its own approach towards the extent of production or regulation of foreign technology, the establishment of a screening mechanism will enable the continuous and systematic monitoring of foreign technology inflows, which does not exist in many developing countries at present.

The above suggests that methodologies will need to be developed to evaluate alternative technologies in terms of overall costs and benefits. This could necessitate the defining of numerical values for critical parameters such as labour costs and shadow wage rates, foreign exchange costs and shadow prices and thereafter the application of a discounted cash-flow approach. While the information network should provide the basic information regarding alternative production techniques, the evaluation of alternatives would need to be done by developing country enterprises and the national agency with responsibilities for reviewing arrangements.

Adaptation and absorption of technologies

Policies of technology adaptation and absorption should focus on the process of ridding imported technologies of their rich country "ethnocentricity" and of stamping them with the societal imprint of the importing country. No less important will be the process of upgrading local technologies to improve their productivity.

The adaptation of imported technology may necessitate, for example, the scaling down of the technology to the size of the local market, a process that has already been satisfactorily demonstrated in several fields, including bricks and cement, paper, textiles, packaging, sugar and a wide variety of agricultural equipment. Adaptation will also necessitate the matching of the technology to available

[36] See Hans Singer, *Technologies for Basic Needs* (Geneva, ILO, 1977), p. 32.

[37] See report of the Second Consultative Group on Appropriate Industrial Technology and also reports of the International Forum on Appropriate Industrial Technology.

local skills which, in some cases, may require maximizing its labour intensity and capital savings.

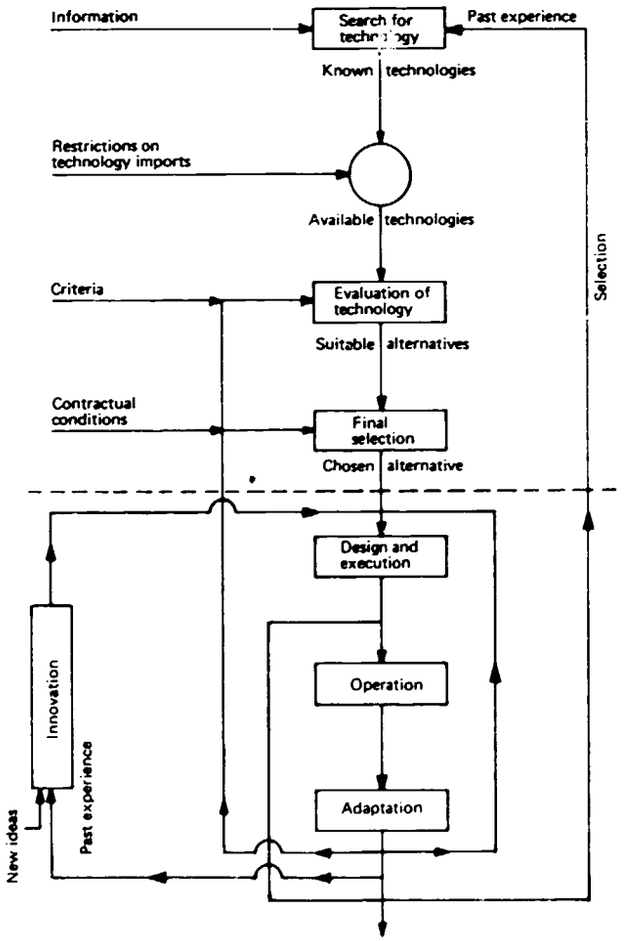
Since technology adaptation is the means of linking imported technology to national R and D, policies designed to enhance capacities for adaptation and absorption will need to give due consideration to the building-up or enhancement of national R and D capabilities. Technology policy will be required to forge closer links between R and D institutions and industries.

Adaptation to the satisfaction of a technical authority could be imposed as a condition in contracts for the acquisition of foreign technology. The costs of adaptation could receive preferential treatment in taxation. Adaptation to local raw materials and components could be secured through a phased programme of reduction of imported materials and components.

The sequence of main activities involved in the processes of technology selection and adaptation is outlined in figure III. The illustration suggests that there are three decisive inputs into these processes: information, the criteria for selection, and legal and contractual practices, each of which has been discussed above.

Absorption of technology in a narrow sense could be facilitated by policies which insist that foreign technology investment inflows be accompanied by adequate training of local personnel both in terms of the number of persons trained and the extent of their training. The passing of a National Apprenticeship Act whereby each industrial unit is required to take a certain number of apprentices for training would also enlarge the pool of trained personnel. Free horizontal occupational mobility has also to be ensured, although there are no known

Figure III. The process of technology selection and adaptation



Source: "The structure and functioning of technology systems in developing countries" (ID/WG.301/2).

direct policy instruments for this purpose. However, general policies that do not unduly restrict the setting-up of new units in the same industry may help incidentally. Policies for attracting the country's technical personnel resident abroad either for permanent settlement or for short-term guidance should also be formulated and implemented, as is already being attempted by a few developing countries.

Long-term policies for the absorption of technology should concentrate on human resource development. Policies that promote a greater involvement of scientists and technicians in the development problems of the country will be needed, including, where necessary, the restructuring of their salaries and responsibilities. This calls for serious reappraisals of educational policies, particularly in respect of the following:

(a) Introduction of a vocational content in the school educational curricula and making such courses available to as large a number of students as possible;

(b) Reorienting the technical courses at the university level so that the awareness of the students of the technological problems in the country, particularly with reference to rural areas, is enhanced;

(c) Educational curricula should include association with industry and practical training.

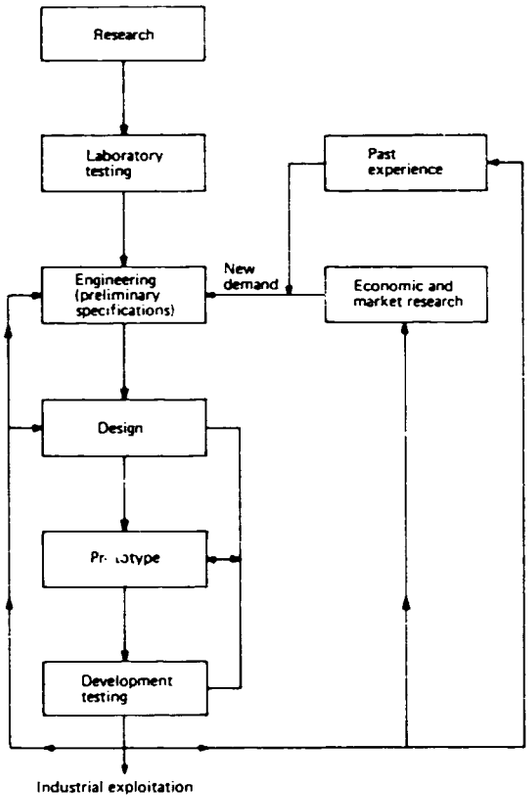
Development of technologies

The development of the capacity to innovate requires much more than the building-up of R and D institutions. In countries where development has been decentralized and community development programmes initiated, experience has shown that local governments, local organizations, agricultural co-operatives and the like, as well as motivated individuals, can be technological innovators. Technological innovation is a bottom-up as well as a top-down process: innovation comes from the users of technology as well as scientists and engineers.

In many cases, however, the technology system is incapable of bridging the gaps between the laboratory, the factory and the market place. This deficiency is due to the lack of integration between scientific and technological activities and the process of industrial production (figure IV). The crucial stage in the process of innovation is the engineering treatment of a new idea. Past experience, coupled with economic study and market research, transforms the scientific idea into a techno-economic reality that can be put through the mill of industrial exploitation and production. This type of activity requires skills that are neither those of the scientist nor of the production engineer, the two professional types most likely to exist in a developing country.

Innovation is not the prerogative of the scientist. The practitioner at any level, particularly at the shop-floor level, as well as the end user are sources of significant innovative ideas of considerable potential.

Figure IV. The process of innovation



Source: "The structure and functioning of technology systems in developing countries" (ID/WG.301/2).

The great advantage of these ideas is that they often reflect first-hand experience and deep insight into the actual needs of the user. They are often capable of producing working models; but considerable engineering effort is needed to transform the basically sound concepts into an economic reality. It is another task of policy to promote the application of such first-hand experience and to facilitate the process of the commercialization of new technologies.

R and D can be promoted through levying a tax on industry and utilizing the proceeds for promotional expenditure. Tax rebates could be allowed on the R and D expenditures of enterprises to encourage them to set up such facilities. In India, it is part of the condition of approval for the import of technologies that the importing organization should set up R and D facilities within the period of the contract so that the need for continuing the import beyond that period is obviated.

To preserve traditional technologies and capabilities, protection could be provided by way of the reservation of lines of manufacture, policies of government purchases etc. The adoption of technologies developed locally (e.g. by research institutes

or industrial enterprises) could be encouraged by tax or interest concessions or by liberal conditions of industrial approvals.

For widespread dissemination of technology and for encouraging innovative capabilities, the promotion of self-employment and techno-entrepreneurs should be encouraged as a matter of policy. Concessional financial assistance through financial institutions are important in this respect. Policies of worker participation in production and technology d sions are of help. Patent laws and financial er couragement for innovations and their application are necessary. Special incentive schemes aimed at universities and academic institutions designed to promote innovative activities may also need to be devised.

In the section on technology programmes, a number of special instruments for promoting technology adaptation, absorption and development will be discussed.

Policies concerning transnational corporations

A substantial increase in the flow of technology to developing countries must take place if an adequate pace of industrial growth is to be achieved. Since, in a large number of manufacturing and service sectors, transnational corporations retain oligopolistic control over technology, a considerable proportion of technology acquisition may need to take place through their operation. Technology plans and policies should thus channel the operation of transnationals according to national objectives and priorities.

Policies aimed at regulating the activities of transnational corporations should recognize the conflict between the profit-maximization objective of transnationals on the one hand and the development of national scientific and technological capacities on the other. These conflicting interests can only be harmonized and the negative impact for developing countries reduced by the introduction of a regulatory and monitoring system. Elements of this control function should focus on the extent of the local integration of the foreign subsidiary, including the utilization of technologies appropriate to the country's needs and conditions, the extent of the utilization of local resources, and the extent to which it is involved in the building-up of indigenous capacities. The exercise of the control function should be guided by the need to secure decision-making autonomy in the host country.

Once technological needs have been defined and the most appropriate technology mix identified, the specific role and the possible pattern of corporate relationships with transnational corporations in various sectors of the economy can be established. In certain branches, particularly high-technology industries, it may be necessary to utilize transnationals both as sources of investment and as suppliers of proprietary technology. In sectors where the domestic industry has the necessary entrepreneurial capability and technological base, technological needs may be served by licensing and other contractual arrangements without foreign capital participation. In certain fields, in order to utilize and enhance domestic innovative capability, it may not be desirable to encourage foreign technology flows, for instance, in sectors where appropriate domestic technology is available or where foreign technology has been adequately absorbed by domestic industrial enterprises.

The technological requirements of linkage industries constitute an important element of negotiations with transnationals. In the case of mineral industries, for example, technology for down-stream processing stages is an important aspect to consider and the interests of both the host country and the enterprise should be harmonized. Similarly, the extent and nature of domestic integration and the increase in value-added over a specific period should be established in the course of negotiations. The development of domestic marketing and managerial expertise, as well as operational skills, should also be identified as an important responsibility of transnationals in various sectors.

An important aspect of negotiations with transnational corporations is the disaggregation of the technology package. Transnationals tend to aggregate the investment function with the various technology elements, including project engineering, production technology, management and marketing. From the viewpoint of the host developing country, it is important that the package should be unbundled and evaluated in terms of its various elements. Of even greater importance is the possibility of the participation of domestic industry in the supply of inputs and project engineering services. Even if the cost of domestic goods and services tends to be above world market prices in the earlier stages of industrialization, this may be justified in the long-term interests of the development of domestic capabilities. The extent of unpackaging may, however, be limited in certain sectors where transnationals can ensure that the technology is used only by a subsidiary or affiliate under its control or sold only as a complete system and not as separate components. Similarly, where foreign engineering contractors with the skills to combine various inputs are themselves dependent on the technology supplier, the incentive to unpackage may be weak or lacking. In such cases, a great deal may depend on the technical and managerial expertise and contracting skills available in the host country. Some countries have, accordingly, placed great emphasis on the development of domestic capabilities in consultancy services.

Efforts in the direction of unpa aging should obviously aim at maximizing the use of local inputs, especially technological services. Policy guidelines can

be prescribed concerning restrictions in the use of foreign personnel, training programmes for domestic personnel at various levels, and enterprise-level R and D. Import restrictions and controls can significantly affect greater technology flow for linkage industries and adaptive use of local materials and parts. Export incentives and insistence on export commitments by the subsidiaries of transnationals can, on the other hand, improve the balance of payments performance of transnationals and achieve better quality production.

It is important that the impact of operations of the subsidiaries and affiliates of transnational corporations on domestic technological development be monitored continuously. The review process should monitor the path of technological development, the R and D undertaken by the foreign affiliate, and the adaptations performed to suit local conditions and requirements. This review should cover existing subsidiaries and affiliates and also new enterprises in which transnationals are involved.

Special attention may also need to be given to the high costs resulting from the extensive use of foreign brand names and trademarks by transnational corporations. Measures that can be used in this respect include the compulsory use of domestic brand names which, after a certain period, obviates the need for foreign brand names. The diffusion of foreign technology can be facilitated by restrictions on the duration of licensing agreements (usually from 5 to 10 years). The shortening of the period of patent validity below the norms of the international patent system can also be introduced, as has been done by such countries as Brazil and Mexico, and the possibilities for introducing patents in vital sectors can be severely restricted.

Technology programmes

Technology policy will have to be translated into programmes and, eventually, subprogrammes, projects and specific activities.

Development of the engineering and machine tool industry

One of the most important of all industrializing industries is the engineering and machine tool industry. It is the basis for much industrialization, and experience in developing countries has shown that a broad-based industrial structure cannot be sustained without the existence of a growth-oriented engineering sector. The engineering industry is traditionally an important source for the growth and development of technical manpower and a focus for the process of technological innovation; it is thus advisable for all developing countries to assign high priority to its development, and especially to the production of machine tools.

The development of the engineering sector may call for the setting-up of facilities for the production of ferrous and non-ferrous castings, forgings, machine tool and machine shop equipment, fabrication (including weldments and stampings), rolling, bending and pressing facilities, heat treatment and plating and steel rolling mills.

Raw material supplies will be of decisive importance, especially steels, castings and forgings. With respect to steel, construction steel (mild steel), alloy steel and sheet steel are the raw materials essential for engineering products. Whether a developing country should develop its own iron and steel industry depends upon a complex of factors, not the least important of which is the availability of necessary mineral resources. Developing countries that have no supplies of iron ore or coal, do not have abundant power and have not reached a high level of industrial development should import whatever steels are required to develop their engineering industry.

The availability of ferrous and non-ferrous castings depends upon the existence of foundries and forge shops, whose development should thus, where necessary, be afforded high priority. Since casts and forged components are to be made specifically to drawings, they can be more advantageously produced in the country itself.

The decision to develop a national machine tool capability should not be made dependent upon the size of market. Virtually every artefact is made on machines that are themselves made on machine tools. Even in the least developed countries a machine tool industry can and should be developed. It might, for example, be organized as a cottage industry and involve the production of essential spare parts.

Small and medium-sized enterprises

Special programmes may be required to promote the technological development of small and medium-sized enterprises. An environment that encourages small firm initiative is likely to be more competitive and able to promote an active search for more appropriate technologies. A small firm is usually less inclined towards vertical integration so that it is more likely to rely on small, relatively labour-intensive local producers and suppliers than is a large enterprise. Small-scale industries also have a critical role to play in integrating the agricultural and industrial sectors, a key aspect of development policy.

In some developing countries, transnational corporations receive more privileged treatment than local small and medium-sized enterprises that typically receive little support in dealing with the problems they face. They generally lack, for example, the necessary resources to maintain specialized personnel for technological management and do not even have enough technicians to adequately maintain and supervise ongoing production processes.

The effectiveness of small and medium-sized enterprises could be improved through support programmes involving R and D institutions, industrial extension services and technological service organizations. Governments might seek to develop entrepreneurial skills in small and medium-sized enterprises through programmes aimed at reducing the risks incurred by groups of entrepreneurs in the development of their technological capacities.

Development of a technological service capability

Inadequate technological service capability is a major constraint in most developing countries. Such services range from macro-level project identification, feasibility studies, plant specifications, detailed engineering designs, civil constructions and machinery installation, and plant commissioning, start-up and operations. While the extent of the gap varies from country to country, the most significant gap, even in fairly industrialized developing countries, is in respect to detailed engineering and designing and sectoral consultancy services through nationally owned units. This makes disaggregation of foreign technology packages extremely difficult and also creates a critical gap in infrastructure, which result in undue dependence on foreign design and engineering services which affects the pattern of investment for particular projects, the requirements of capital goods and equipment, and subsequent plant operations and management. In the less developed economies, the gaps in consultancy services are even more marked and extend to almost the entire range of service activities indicated above. The identification of gaps in service capability has to be done on a country-wide basis and for critical and priority sectors in each economy. An appropriate policy package also needs to be prescribed and the extent to which preferential treatment is necessary for national or regional consultancy services, including engineering and designing capability, needs to be defined and necessary norms and guidelines identified regarding the use of such domestic capability in a progressive manner at successive stages of industrial growth. It may also be necessary to provide technical and financial support to national consultancy firms undertaking detailed engineering and other technological services, particularly in priority production sectors. Fairly effective steps have been taken by certain developing countries, notably India, in this field and similar action can be emulated in other developing countries, with appropriate adjustments to suit national or regional considerations.

Technological services include the promotion of standardization, quality control, common testing facilities, productivity, metrology and other such general service functions. There are a number of institutions in developing countries in several of these fields. Such institutional activities are usually supported by governments or are financed through universities or research organizations. In many countries, standardization and quality control have made effective progress and have constituted an essential feature of export promotion of non-traditional products. Productivity organizations have also proved useful in identifying specific production problems at the micro-level in several industries though, by and large, there has been limited communication and linkage with production sectors and enterprises.

Industrial extension services

The processes of technology adaptation, absorption and development would no doubt be facilitated by the creation of industrial extension services. Such services, which would parallel those applied in agriculture, could serve to accelerate the growth of manufacturing industry, especially in small and medium-sized enterprises, and, in time, provide an important input into the strengthening of national research and development activities.

Industrial extension services could be used:

"(a) To identify and resolve, to the extent possible, problems faced in manufacturing. It may be necessary, however, to refer the more complex problems to R and D institutions for advice or resolution;

"(b) To identify new areas for the adaptation and development of appropriate technologies. Such areas might include leather, processed food, metallurgy, forest products and building materials. The work would be undertaken either in the extension centres themselves, or in indigenous R and D institutions, according to needs and resources;

"(c) To familiarize industries within the country with development and improvements in related techniques;

"(d) To train local professionals;

"(e) To provide essential support for future expansion into R and D institutions and assist in the growth of other institutions."[38]

Information networks

Special programmes in the field of information may need to be initiated. There will be a need for an adequate information network that can ensure a flow of fairly detailed data and material on production and technical requirements projected both for the economy as a whole and at the micro-level with specific growth projections and technical requirements of significant production sectors and enterprises. Once the nature and magnitude of sectoral growth projections and technological requirements

[38] See *Cooperation for Accelerating Industrialization: Final Report by a Commonwealth Team of Industrial Specialists* (London, 1978), pp. 30-31.

are defined, the information system should also be able to provide possible technological sources, both indigenous and external and for specific projects and enterprises. At the micro- or enterprise-level, the information mechanism should provide for detailed data flow regarding existing industry in terms of *(a)* production capacity in various or selected sectors, production techniques employed, utilization of capacity and technological problems encountered; and *(b)* the nature of the expansion proposed, with its technological implications. The flow of information should also cover the need for new enterprises that may have to be set up to cover critical production gaps in various sectors.

Technical education and training programmes

Technological self-reliance is linked to education and training, which is linked to the process of confidence building. The promotion of technological self-reliance should thus be seen as a learning process in which the emphasis is on thinking in terms of independence and the need for autonomous decision-making.

Education is a basic element of the scientific and technological infrastructure of the country. Because of the complexity and overriding importance of the educational system, however, the design of this system should be left to institutions that deal specifically with it. Education should fulfil the dual function of instilling appropriate values and attitudes and upgrading and developing necessary skills. Technology and education plans should thus be closely interlinked. Training at the production level–that is, in its actual operation in the factory and the agricultural sector that directly influences the adaptation, absorption and diffusion of technology–falls within the framework of technology policy.

The strengthening of technological capacity requires:

(a) Making science education more responsive to the needs of the country and using science and technology effectively in the achievement of national goals;

(b) Stimulating the choice of scientific and technology education and careers to increase the number of scientists, engineers and technicians;

(c) Reinforcing the social status and prestige of technical and technological work;

(d) Emphasizing and stimulating imaginative inquiry and independent learning.

Well-defined training programmes for the development of special skills in specific industrial operations and technological services will be necessary. Short-term training programmes may include, for example, processing technological information; training of managers, entrepreneurs and government officials in the evaluation, negotiation and acquisition of technology; training of research and development personnel in the management of research and development, evaluation of research and development projects, commercialization, extension work, liaison with industry and other related matters. Training programmes and sensitization courses may be necessary for policy-makers in project and technology evaluation and the implications of choice of technology. Special courses may be necessary for technical personnel in such aspects as design, production engineering and productivity. In-plant training programmes for engineers and skilled workers will be essential. While some of the programmes referred to could be organized within the country itself with, where necessary, the help of outside experts, there are others where training may need to take place in an industrialized country or be organized within the framework of TCDC efforts.

Special programmes might also be launched to deal with the problems of brain drain. The aim of such programmes should be to enable experts, technologists and managerial/supervisory personnel to return home, even if for only a limited period, so that their knowledge and expertise can be adequately utilized.

The need for action programmes

The development of national technological capabilities requires concerted action in a wide range of interrelated fields. However, it will not generally be possible for developing countries to do everything at once, even if this were considered desirable. There is thus, as noted earlier, an overriding need for selective action in areas that will lead to an immediate and demonstrable improvement in technological capacities.

One area in which such an action programme could yield substantial results is in bringing technology and production into a relationship of co-operative association and mutual reinforcement after, in many developing countries, decades or even centuries of separation. The main elements of such an action programme could include:

(a) The selection of a small number of sectors or areas of production in which there is considerable scope for the introduction of frontier technologies that could be used to spearhead the process of industrial development. These sectors are generally in the industrializing industries. In other sectors, technology would still play an important role as one of the major factors of growth and production but these would not be afforded such strategic importance. In a third group of sectors or areas of production, there would be no determined efforts to stimulate technology development much beyond current and available levels;

(b) In the high priority sectors and production areas, special efforts should be made to create "integrated technology development, upgrading and application systems", both at the level of the enterprise and of broad policy;

(c) For this purpose, expenditure on technology selection, acquisition, adaptation, absorption, development and application in the selected sectors may need to be expanded to perhaps 10 times the current average level of expenditure for the rest of the economy. National policies and other public and private institutional programmes and instruments should be developed and applied to ensure the desired results;

(d) The supporting services, skills, legislation and regulations required should be gradually expanded to serve as an indigenous basis for promoting the development of other sectors, thus ensuring that there is a general advance not only in technology, but also of social and economic development.

In this manner, real progress could be made in a number of high priority sectors that would facilitate the process of development-centred industrialization. A stronger technological basis could be established and closely integrated with production, management and investment in the country concerned. The process would be inevitably long-term and it could take five years or more before it started to bear real fruit; it is a dynamic process and this dynamism could serve to give real expression to the concept of technological self-reliance. Although the technology used may be imported or traditional, or both, it would always be the result of decisions taken by qualified technologists and technicians who would seek to choose the optimum technology and technology mix within a dynamic and development oriented framework.

The action programme outlined could also utilize the idea of industrial development complexes that could serve as a focus for the implementation of mutually reinforcing sets of proposals. Such complexes might aim at bringing together a group of related enterprises and technologies to form a co-ordinated vertical system with an enhanced capacity for innovation and technology development.[39]

Institutions

Policies and programmes are formulated and implemented by institutions. Their value resides in the fact that they provide a measure of continuity and experience and in due course become the repositories of technological capabilities. Although they have a decisive role to play in the promotion of technological self-reliance, institutions can only be as good as the policies and programmes that they implement and as effective as the means that they have at their disposal.

Unfortunately, a good deal of the literature on technology policy has given the impression that the implementation of policy calls for the creation of new institutions, or even of a single omnipresent institution in which the "technology function" is centralized. Yet there can be no watertight boundaries for defining all the elements of technology policy and, in its implementation, there is a wide range of "implicit" instruments that, although not usually applied by technology institutions, are able to influence technological development in crucial ways.

Conceivably, if a nation were to set out to build an administration from scratch, all the areas affecting technology development could be separated and grouped together for institutional purposes. But no country does start from scratch and most already have a range of institutions that deal, in various ways, with aspects of technological policy. Developing countries typically possess ministries of science and technology, technology transfer centres, sectoral industry development centres, research institutions of various types, information centres, technology regulation agencies etc., each performing one or more technological functions. The difficulty of attempting to disentangle technology as a separate policy area is not surprising given that the area encompassed by technology is virtually co-extensive with that of economic progress, since technology in part determines productivity and productivity influences incomes. Because one of the principal aims of all policies implemented by all government institutions is the fostering of economic progress, few governments think it productive to separate such policies and to consolidate them institutionally. The same applies to technology policy.

Clearly, then, the process of developing technological capabilities is far too complex to become the exclusive domain of a single institution, and the development of appropriate institutional infrastructure lies in the strengthening of existing institutions rather than in the creation of new institutions. There may of course be both the scope and need for new institutional initiatives but, as a general rule, the creation of new institutions only appears justified where there is a role for them that is demonstrably different from the functions of existing institutions.

A balanced approach to institution building will have to start from the functions, capabilities and services required and a review of how these can be most effectively made available or linked to entrepreneurs on the one hand and government officials and policy-makers on the other. Apart from

[39] The development value of such complexes is discussed in "The effectiveness of industrial estates in developing countries" (UNIDO/ICIS.32), May 1977.

institutions for technical education and training, at least three basic types of institutional functions may be required. One type relates to technology policy formulation and monitoring at the macro-level and technology screening and evaluation at the micro-level. These functions will generally have to be fulfilled by a government department or agency, suitably located in the governmental hierarchy so that it is able to influence decision-making. Another type of institutional function relates to technological information, evaluation and consultancy assistance to entrepreneurs. This may have to be performed by an agency, governmental or quasi-governmental, which maintains effective relations with government, financial institutions and industry. The third type of function relates to technology development, adaptation and commercialization with facilities for consultancy and extension work. Such a function needs to be exercised by research institutions or technology development centres, which may be single or multi-sectoral, depending on requirements.

Several of these functions will need to be injected into ostensibly non-technological institutions, such as ministries of industry, planning, trade and finance, and financial and banking institutions. Sectoral industry centres should function as technology adaptation and development centres. Technological diffusion, particularly in the rural areas, may require institutional innovations such as those adopted in India, including the creation of small industry centres, district industry centres and polytechnology clinics (i.e. extension and consultancy outposts of research institutes).

Some of the more important steps that a developing country may need to take in the development of its technological institutions are summarized as follows:

(a) Examining whether adequate institutional arrangements exist for the exercise of technological functions;

(b) Strengthening existing institutions or networks of institutions, to ensure that they are able to exercise such functions;

(c) Creating new institutions where existing institutions are unable to effectively exercise their required functions;

(d) Ensuring adequate linkages and co-ordination between the institutions, government and industry;

(e) Providing the institutions with adequate manpower, material and financial resources;

(f) Developing institutions for technical education and manpower training;

(g) Reorienting the programmes of the institutions towards problems of national development, especially those associated with strategies of (technological) self-reliance and aimed at meeting the basic needs of the poor and underprivileged masses;

(h) Instilling an awareness of possible technological impacts into the operations of relevant non-technological institutions;

(i) Creating organic linkages between technology institutions and decision-making for social and economic development;

(j) Providing appropriate encouragement to voluntary agencies and universities so that they can become catalytic agents in the promotion of technological self-reliance.

There is likely to be considerable scope in most developing countries for experimentation in the field of institution building. In countries with a weak technological base, it may be necessary to create national technology centres vested with a broad range of responsibilities. Because of the enormous variety of technological situations in the third world, no single blueprint for such a centre can be hypothesized. Its core functions might, however, be to:

"(a) Assist, within the framework of national, social, economic and political constraints, in the identification of technological needs for a variety of economic activities;

"(b) Assist in the acquisition and analysis of information required on alternative sources of technology from all available sources, domestic and foreign, and its delivery to users;

"(c) Assist in the evaluation and selection of technologies appropriate for the different jobs to be done, with the emphasis on decision-making;

"(d) Assist in the unpackaging of imported technology, including assessment of suitability, the direct and indirect costs and the conditions attached;

"(e) Assist in the negotiation of the best possible terms and conditions for the technology to be imported, including arrangements for the registration, evaluation and approval of agreements for its transfer;

"(f) Promote and assist absorption and adaptation of foreign technology and generation of indigenous technology, linked specifically to design/engineering, research and development;

"(g) Promote the diffusion among users of technology already assimilated, whether indigenous or foreign;

"(h) Co-ordinate policies in general and evaluate their internal consistency in relation to the transfer and development of technology."[40]

In view of the observations made above, it would be appropriate to determine whether such functions

[40] See *Handbook on the Acquisition of Technology by Developing Countries* (United Nations publication, Sales No. E.78.II.D.15), p. 41.

could best be met by a network of existing government agencies and private institutions implementing an interrelated set of policies and programmes at different levels (figure V).

Some developing countries might also find it useful to establish a national centre for development alternatives for the purpose of conducting multi-disciplinary and multi-institutional studies into alternative development systems that are man-centred, need-based, endogenous and self-reliant and into the possibilities for change in and development of the national science and technology system.[41]

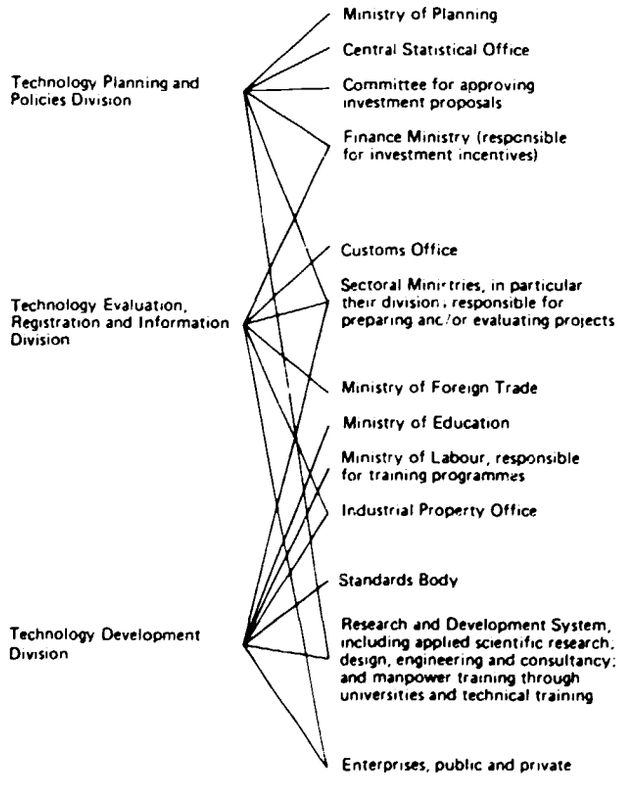
Monitoring of technological strategy

Developing countries should continually review and evaluate the process of technological change and the efforts made to strengthen technological capabilities. This evaluation should seek to clarify the relationships between ends and means in technological policy and to assess the effectiveness of the programmes and projects initiated. The evaluation of technology policy and of efforts in the direction of technology planning should be made in the light of national development aims and aspirations and of economic, social and industrial development objectives. If the development of technological capabilities and the promotion of technological self-reliance are to be treated as more than mechanical exercises in manpower projections, then it is essential that the monitoring and evaluation system developed should be a derivative of development strategy and focus on problems related to human resource development and the mobilization of national problem-solving capacities.

Especially important is the monitoring of foreign technology flows and their impact on domestic technological progress in specific sectors as well as on changing technological needs. The absorption and diffusion of foreign technology following its adapta-

[41] See "Science and technology for development - indigenous competence building" (ID/WG.301/3), June 1979, pp. 12-17.

Figure V. Possible network of linkages of a national centre for technological development



Source: *Technological Transformation of Developing Countries*, Discussion Paper No. 115 (Lund University, Research Policy Program, Sweden, 1978), p. 26.

tion is also an area that should be subject to continual review.

The institutional arrangements or monitoring and evaluation will vary from country to country. It is essential, however, that the institution or group of institutions vested with monitoring responsibilities should be in the mainstream of technology policy formulation and implementation. It should have sufficient authority to speak instead of being merely represented at, for example, interdepartmental consultations on technology policy. The monitoring authority should have its own budget and be in a position to allocate funds to different bodies for the purposes of policy evaluation and review. It should make and publish periodic reviews of progress in the direction of strengthened technological capabilities and be able to relate such reviews to progress in the direction of development goals. It is essential that the monitoring and review body, irrespective of its exact composition or structure, does not become another department lost in a bureaucracy or in routine and administrative tasks.

IV. Role of international technological co-operation

A. Issue of international technological co-operation

The countries of the third world will be unable to strengthen their technological capacities unless they themselves become the active agents of their own transformation through their own efforts and the application of their own resources and knowledge. The pursuit of increased self-reliance, however, even when aimed at more selective participation in the international economic system, in no way excludes technical co-operation with other nations, both developing and developed.

Since the technology needs and experience of many developing countries bear close affinity and follow similar patterns, co-operation between developing countries will be invaluable in the process of collectively strengthening technological capabilities Equally, the industrialized countries will remain the predominant suppliers of much modern technology. Co-operation with the governments of and enterprises in these countries will be required to ensure that the transfers that take place contribute to, rather than undermine, national development efforts. In both these areas–technical co-operation between developing countries and between developing and industrialized countries–there is considerable scope for new approaches and fresh initiatives.

B. Co-operation between developing countries

A great deal of attention has been focused in recent years on the potential offered by ECDC and TCDC. It is recognized that they constitute an important framework for the forging of bilateral links of co-operation at the subregional, regional and interregional levels. The *Buenos Aires Plan of Action* lists the objectives of TCDC as follows:

"(a) To foster the self-reliance of developing countries through the enhancement of their creative capacity to find solutions to their development problems in keeping with their own aspirations, values and special needs;

"(b) To promote and strengthen collective self-reliance among developing countries and through exchanges of experiences, the pooling, sharing and utilization of their technical resources, and the development of their complementary capacities;

"(c) To strengthen the capacity of developing countries to identify and analyse together the main issues of their development and to formulate the requisite strategies in the conduct of their international economic relations, through pooling of knowledge available in those countries through joint studies by their existing institutions, with a view to establishing the new international economic order;

"(d) To increase the quantum and enhance the quality of international co-operation as well as to improve the effectiveness of the resources devoted to over-all technical co-operation through the pooling of capacities;

"(e) To strengthen existing technological capacities in the developing countries, including the traditional sector, to improve the effectiveness with which such capacities are used and to create new capacities and capabilities and in this context to promote the transfer of technology and skills appropriate to their resource endowments and the development potential of the developing countries so as to strengthen their individual and collective self-reliance;

"(f) To increase and improve communications among developing countries, leading to a greater awareness of common problems and wider access to available knowledge and experience as well as the creation of new knowledge in tackling problems of development;

"(g) To improve the capacity of developing countries for the absorption and adaptation of technology and skill to meet their specific developmental needs;

"(h) To recognize and respond to the problems and requirements of the least developed, land-locked, island developing and most seriously affected countries;

"(i) To enable developing countries to attain a greater degree of participation in international economic activities and to expand international co-operation."[42]

[42] *Report of the United Nations Conference on Technical Co-operation among Developing Countries* (United Nations publication, Sales No. 78.II.A.11), pp. 5 and 6.

TCDC should thus be viewed as a multi-dimensional process that should prove of decisive importance in enabling the third world to free itself from some of the worst forms of technological dependence and domination.

The need for intensified TCDC arises not only from the recognition that the developing countries cannot rely solely on the goodwill and participation of enterprises from the industrialized countries but also from the awareness that the technological needs and experience of the developing countries have, by and large, common elements. The technological capabilities of several developing countries have achieved a level where their know-how, expertise and services, supported by supplies of machinery and equipment, can be effectively transferred to other developing countries at both the government-to-government and firm-to-firm level. The sectors in which such capabilities have been developed extend over the production of a wide range of consumer durables, intermediate products, light and medium engineering goods, and machinery and equipment. In all these areas, developing countries are effectively competing in international markets. Technological service capability, for example in consultancy and engineering services, has also grown considerably in many of these countries and could be extended to other developing countries. Most of the process and production know-how in these countries have been acquired through foreign affiliates, joint ventures and former licensing arrangements, though a large number of locally developed processes and techniques have also been developed. Both these categories of technical know-how can be effectively and appropriately transmitted between developing countries.

Most prospective developing country licensees continue to seek assistance from Western transnational corporations, even for relatively unsophisticated production processes for which there is a fairly wide range of technological choice available in other developing countries. This is partly due to a lack of knowledge of the availability of appropriate technology and technological expertise and know-how in other developing countries and partly to a continuing preference for more sophisticated production techniques used in highly industrialized countries. Closer contacts and greater sharing of knowledge and experience between developing countries would improve this situation.

An important prerequisite to greater technology flow between developing countries is the compilation of a new set of guidelines and principles in respect to technology transfer arrangements between enterprises. Licensor enterprises from developing countries should not impose unduly restrictive contractual conditions on licensees in other developing countries as was often done by technology licensors from industrialized countries. On all critical negotiable issues, such as the extent of foreign holding, duration of agreement, technology remuneration, technical service support and other contractual conditions, new standards and principles should be set and agreed upon, based on a maximum degree of co-operative partnership. A set of model guidelines should be prepared and developing countries should ensure that the guidelines are applied by licensor-licensee enterprises. With the greater degree of control exercised in most developing countries over the production sector, it should be both feasible and practicable that such guidelines, agreed upon at the intergovernment level, should be universally applied in technology and investment cum technology transactions between developing country enterprises.

Other areas in which there is considerable scope for technological co-operation between developing countries include: *(a)* exchange of information and experience regarding technology licensing and contracts; *(b)* collective adoption of guidelines governing foreign technology inflow and regulation; *(c)* joint action in the selection of appropriate know-how in certain sectors; *(d)* collective bargaining for the licensing of a particular technology for similar projects in more than one developing country; *(e)* development of joint R and D facilities for selected production sectors; and *(f)* joint manpower training programmes in selected branches.

An exchange of information and experience on the terms and operation of technology contracts would greatly strengthen the bargaining power of the developing countries because of the greater knowledge and information they would have at their disposal and the extension of the area of technological choice.

UNIDO has suggested that the information that could be shared to great advantage between developing countries could be broadly categorized as follows:

"(a) Available alternative sources of technology;

"(b) Terms and conditions of acquisition of specific technologies;

"(c) Terms and conditions of supplies of raw materials and intermediates;

"(d) Sectoral trends in terms of applicable royalty rates, technological developments etc.;

"(e) Corporate ownership and structures of various suppliers of technology etc.;

"(f) The availability of skilled manpower and expertise in various countries."[43]

Of particular importance is specific information on prices of know-how, engineering, technical services etc.; applicable royalty rates; methods of calculation of running and fixed payments; prices and terms of delivery of raw materials, components and inter-

[43] See "Technological cooperation between developing countries . . .".

mediate products; scope of sales and manufacturing rights; limitations of volume of production/sales; duration of agreements; and parties to agreements.

In respect of policy guidelines governing foreign technology contracts, a similar pattern and approach has already been adopted in most developing countries where such contracts require to be reviewed by regulatory institutions. As pointed out earlier, however, model guidelines should be prepared for other developing countries where such institutional arrangements still need to be established. These could be considered and adopted in the light of each country's specific situation and objectives.

An important field of technological co-operation relates to the joint acquisition of technology and know-how for use in several countries through a process of collective bargaining. Though seemingly difficult, this has considerable possibilities, both for technology suppliers and for recipients and licensees. There is considerable commonality in industrial programming in countries in comparable stages of development and projects in the same field could be undertaken in more than one country about the same time. Such projects could include large-scale industries, such as steel, petroleum, fertilizers and chemicals, and machine building; medium-size plants for textiles, sugar, cement and agro-industries; and small-scale units covering a wide range of intermediate and consumer products. In a number of these cases, the acquisition of foreign know-how on a collective basis for more than one project could be considered. This would enable more detailed evaluation and consideration of technological alternatives and would reduce technology costs in addition to securing better contractual terms. Such an approach towards collective bargaining would have particular significance in contiguous countries, as in the case of the Andean Group or regional country-groups in Africa and Asia. It would also have relevance for countries at a similar stage of industrial growth, such as Brazil, India and Mexico. Significant collective action has not so far been initiated in the acquisition of technology primarily because this issue has been viewed in national terms and left to the initiative of individual enterprises. With the increasing realization of the interrelationships in technological growth, a joint or collective approach to technology acquisition appears particularly important.

The institutional arrangements for the joint acquisition of technology should also be considered. They can take either the form of joint negotiations by a group of developing countries for identified sectors in which the country-groups are interested or the establishment of an international mechanism through which technology can be acquired and transferred to projects in more than one country. The former approach necessitates close collaboration and co-ordination between country-groups and the identification of common technological needs in specific industrial sectors, after which a joint body can be constituted for evaluating, negotiating and acquiring selected technology in the fields identified. The second alternative requires the creation of an appropriate international mechanism through which such joint technology transactions can be channelled. UNIDO could function as such a mechanism.

TCDC should be intensified in respect to consultancy and engineering services and the development of manpower skills, including managerial expertise. Hitherto, linkages in these fields have been established primarily at the enterprise level between licensees and foreign parent organizations and technology licensors from industrialized nations, though some joint training programmes have been undertaken in some developing countries. There is considerable scope for the setting-up of joint consultancy and engineering services, either on a regional basis or between country-groups at a similar stage of industrial growth. The first step in this direction is the greater use of consultancy and engineering services available in certain developing countries by other developing countries, followed by the creation of appropriate national consultancy services in each country or in regional groups.

Co-operation in research and development programmes is another promising field. Such co-operation would help to ensure that R and D is better geared to meeting the developmental needs of the developing countries. Experience of industrial R and D in the institutions set up in developing countries has, at best, been fairly mixed, which emphasizes the need for the systematic sharing of experience and the implementation of joint research activities. Electronics, drugs and pharmaceuticals and non-conventional sources of energy are high priority research areas. They could be followed by joint R and D programmes in agro-industries, leather, chemicals, engineering products and several other sectors of interest to a number of developing countries. It is essential, however, that R and D programmes are directly related to the needs of the production sector and, though the results of industrial research can only be assessed over a relatively long period of, say, from three to five years, such an assessment has to be made in terms of changing costs and benefits. Cost-benefit analyses in terms of utilization of research results by industry are all the more necessary and significant for joint programmes.

While the part played in TCDC by institutions and enterprises is important, governments also have a crucial role to play in defining the nature and extent of TCDC programmes and in monitoring and evaluating their effectiveness. It will be necessary, therefore, for developing countries to arrive at intergovernmental framework agreements that specify the nature, extent and modalities of TCDC and provide a framework within which to conclude bilateral and multilateral agreements in different fields and at different levels.

The Round Table Ministerial Meeting on Industrial and Technical Co-operation among Developing Countries, organized by UNIDO and held at New Delhi in January 1977, detailed specific areas of technological co-operation as follows:

"(a) Co-operation in the field of industrial technology with a view to improving the identification and use of technologies already available in the developing countries, including technical know-how and skills, machinery and equipment, design, consulting and construction capabilities;

"(b) Collaboration in respect of the proposal for a technology bank, which would also include consideration of joint purchase of technology and examination of contracts and agreements already concluded, to provide guidance to others so as to avoid the mistakes and problems relating to the experience of particular technologies in any of these countries;

"(c) Promotion of collective action for negotiating and bargaining for more equitable economic relationships and for acquisition of technology;

"(d) Development of concrete programmes for using engineering and consultancy capabilities available in the developing countries;

"(e) Co-ordination of industrial training programmes to augment the skills considered basic to industrial development programmes;

"(f) Co-operation in the establishment and strengthening of national and regional institutions concerned with industrial and technological development;

"(g) Co-operation in applied research and development in specific sectors, drawing upon machinery and capabilities already available in the developing countries and concentrating specifically on engineering industries, electronics, fertilizers and agro-chemicals, pharmaceuticals, chemical industries and energy."[44]

C. Co-operation between industrialized and developing countries

Bilateral and multilateral technical co-operation between industrialized and developing countries has increased considerably in the past decade or so. Evidence indicates, however, that past patterns of co-operation have not only strongly reflected but also tended to reproduce the disparities in the technological capabilities of the rich and poor countries. Certain types of well-meaning co-operation have tended to be wasteful in their use of resources, ineffective in terms of their contribution and, when they have involved the transfer of "ready-made" solutions and the conscious and deliberate transmission of value systems, consumption patterns and ways of thinking in the Western industrialized countries, may have contributed to the problems of developing countries.

The efforts of the third world to strengthen its technological autonomy should be underpinned by well-conceived international, multilateral and bilateral programmes of technical co-operation. The reports of many of the conferences held in recent years by United Nations bodies reflect this belief and refer to the importance of science and technology in the development process and to the valuable role that can be played by programmes of technical co-operation.

A study made of the results of such conferences points to areas in which the industrialized and the developing countries have reached a large measure of agreement.[45] These covered balancing of the "flow" and "stock" streams of science and technology, emphasis on "appropriate" technologies, stopping the "brain drain", participation of the developed countries in solving problems of concern to the developing countries, more technical co-operation between the developing countries and the satisfaction of basic human needs.

The consensus implied is stated in general terms and has yet to be put to the test; also the listing takes a predominantly instrumental view of science, technology and co-operation. However, there is evidence of a foundation upon which to construct new approaches to scientific and technical co-operation.

It is not the validity of technological co-operation that should be questioned, but rather the relevance of past approaches. There appears to be scope for new initiatives which, stripped of ethnocentric prejudices, preoccupations and predilections and free of parochial interests, seek to support the third world in its struggle to free itself from some of the worst forms of technological dependence. If mobilized in the right ways, the technological expertise accumulated in the industrialized countries could stimulate a conscious process of technological change in the developing countries.

For some time to come, enterprises and institutions in the industrialized nations will continue to function as the major source of much industrial technology. With the exception of the centrally planned economies, ownership and knowledge relating to industrial technology will be concentrated in individual enterprises in the developed countries

[44] See "Industrial and technical cooperation among developing countries" (UNIDO/IOD.133), October 1977.

[45] J. M. Logsdon and Mary M. Allen, *Science and Technology in the United Nations Conferences: A Report for the U.S. Office of Science and Technology* (Washington, D.C., George Washington University, Graduate Programme in Science, Technology and Public Policy, January 1978).

and technology flow will continue to take place through various mechanisms, ranging from the supply of capital goods and licensing arrangements to joint ventures and foreign affiliates with varying degrees of foreign ownership. In almost all cases, technology transfer takes place through contractual arrangements between enterprises in these countries and in developing countries and it is the nature and content of the contract that should take the legitimate doubts and aspirations of the developing countries into full account. Given the screening arrangements already operating in many developing countries and those likely to be established, it would be impracticable to expect that unreasonable restrictive provisions should continue to form part and parcel of such contracts, particularly provisions that may not even be legal in the country of the licensor. Representative bodies of technology suppliers and licensors should prescribe and adopt guidelines in technology supply and contracting that are consistent with the requirements of developing countries and licensees from these countries. It is only then that the present mood of confrontation will be satisfactorily resolved and a more appropriate climate created for investment cum technological collaboration at the enterprise level.

There is also a need for a greater flow of technology from a larger number of industrial enterprises in the industrialized countries. The majority of technology transactions between industrialized and developing countries have, in the past, involved Western transnational corporations and large industrial establishments. As noted in chapter I, however, transnationals have not always proved satisfactory agents of transfer. Because they are concerned with world-wide operations they tend to standardize their procedures and processes. As a result, they often become too dominating and inflexible for the development process, especially in small developing countries. There appears to be considerable scope for a range of public-supported initiatives aimed at involving small and medium-sized enterprises in the process of international technological co-operation. Small industries may well prove a more appropriate instrument for the transfer of technology. The smaller scale of operations lends itself to an efficient use of labour-intensive techniques. Capital-labour ratios also tend to be lower in small industries, which suggests that a given amount of investment would generate greater employment if it were allocated to small instead of large industries. Thus, the experience of small and medium-sized enterprises in the industrialized countries is likely to be more relevant to the factor endowments (relative abundance of labour and scarcity of physical capital and skills) of the developing economies.[46]

[46] See A. S. Bhalla, "Small industry, technology transfer and labour absorption", *Transfer of Technology for Small Industries* (Paris, OECD, 1974), pp. 107-120.

Small and medium-sized enterprises have not yet been adequately involved in formal transfer programmes because they lack the capacity to enter into negotiations and co-operative arrangements. This suggests a potential area for new initiatives: the governments of the industrialized countries might consider such measures as the coverage of investment risks, the promotion of contacts through the dissemination of information, and financial support to bring interested parties together. Small and medium-sized enterprises may well have a special role to play in the process of technology adaptation, conceivably within the framework of basic needs strategies.[47]

Research co-operation is typically an area in which several ideas, old and new, still have to be fully tested. Special attention could be given to the promotion of twinning arrangements that lead to direct channels of communication between research institutes in industrialized and developing countries and that facilitate the transfer of know-how and provide a framework for various types of training arrangements, longer-term collaboration and more effective involvement of universities in the industrialized countries in technological transformation activities. Efforts might also be made to launch co-operative research programmes aimed at developing new technologies from which both industrialized and developing countries could benefit, such as small-scale energy modules based on "soft" sources, small-scale electrification systems, low energy housing and transport technologies, and rediffusion systems. Similarly, the governments of the industrialized countries, which are generally able to exert considerable direct and indirect influence over national R and D budgets, could seek to promote research into technologies of special interest to the third world. Whatever the institutional framework selected, however, the resulting programmes should involve the active participation of research workers and institutions from the developing countries so that they can benefit from the experience of working on the solution to some of their own problems.

The governments of the industrialized countries might establish programmes aimed at subsidizing the sale of technological knowledge and product and process know-how.[48] Governments are not generally in a position to force their industries to part with their technological property which, in some cases, may have involved exceedingly high R and D costs and which determines their competitive position in both domestic and international markets. Governments of the industrialized countries could possibly

[47] See Antony J. Dolman, *The Like-Minded Countries and the Industrial and Technological Transformation of the Third World* (Rotterdam, Foundation Reshaping the International Order (RIO), 1979), pp. 76-78.

[48] See Jan Tinbergen, co-ordinator, *Reshaping the International Order: A Report to the Club of Rome* (New York, Dutton, 1976), chap. 14 and annex 6.

seek to overcome some of the constraints involved by agreeing on preferential terms for the sale of various categories of patents and know-how to third world countries, the difference between such terms and those between the industrialized countries being borne by the governments. In this way, the competitiveness of the firms involved would not be disturbed on world markets.

Another approach would be to establish in the donor countries policies that would enable them, as part of their aid policy, to subsidize the sale of technological property to the third world on an *ad hoc* basis. Such policies could focus on the technologies that are controlled by Western transnationals and that would contribute to strengthening the technological research and development capabilities of the recipient countries. Arrangements might also be made for the joint purchase of technology use rights for several firms in a number of developing countries. This could be organized within the framework of support for TCDC.

Technology is embodied in people. Industrialized countries could consider ways in which their specialists could more effectively contribute to the process of strengthening the technological capacities of the developing countries. In this respect, industrialized countries could establish programmes whereby voluntary technical advisers could assist developing countries in such areas as negotiations with Western transnational enterprises, the creation of industrial extension services, and the setting-up or strengthening of local design and engineering consulting services. Assistance could be organized on a government-to-government or firm-to-firm basis.

The exercise of this responsibility may call for the introduction of such measures as codes of conduct, incentives and sanctions. Support for the efforts being made by developing countries to develop their technological capabilities must also be reflected in support for measures designed to protect infant science and technology in the third world at national and regional levels, for automatic financing mechanisms aimed at promoting human resource development and technological innovation in the third world, and for intergovernmental programmes, especially those launched under the auspices of the United Nations, that are aimed at strengthening the technological capacities of the developing countries.

D. Role of UNIDO

In assisting developing countries in their quest for technological self-reliance, UNIDO could continue:

(a) To assist developing countries in a practical manner in developing and implementing a framework for national action towards self-reliance;

(b) To generate an extensive movement for creation of awareness, sensitization and mobilization of interest and effort;

(c) To develop human resources, thereby strengthening technological capabilities in the widest sense;

(d) To develop technology, both processes and equipment, suitable for use by developing countries;

(e) To promote technological co-operation among developing countries;

(f) To develop and promote the concept of technological self-reliance towards operational strategies.

A large number of developing countries have not yet taken effective and systematic measures for technological development. The urgent need at the national level is to create a framework for national action for technological development in the place of *ad hoc* and unco-ordinated efforts. Such a framework has been developed by UNIDO whose technical assistance and technological advisory services will be available to developing countries in elaborating that framework and in implementing several programmes arising therefrom.

The creation of awareness, sensitization of issues and mobilization of interest and efforts is of primary importance. The third meeting of the Consultative Group on Appropriate Industrial Technology felt that UNIDO could perform a major service to developing countries by generating a sustained process in this regard.[49] The International Forum on Appropriate Industrial Technology, including the preparations leading to it, was a major sensitizing factor at the international level. It resulted on the one hand in the evolution of a conceptual and policy framework for appropriate industrial technology, endorsed by the Ministerial Level Meeting; and on the other in a detailed expert examination of technology options and issues in a dozen industrial sectors. The conceptual, analytical and empirical basis for a major effort in appropriate industrial technology will have to be further built upon so as to create a movement for technological development between as large a number of developing countries as possible.

The process of sensitization should include the presentation of technological options available to developing countries in specific industrial sectors. The work of the UNIDO Industrial and Technological Information Bank (INTIB) will need to be enlarged and supported by adequate resources. Special attention should be paid to the collection and dissemination of information on technology available from developing countries and also to the possibilities of co-operation in small and medium-sized industry between developed and developing countries as well as between developing countries themselves. Since INTIB by its very nature has to draw upon a large

[49] "Draft report", Third Consultative Group on Appropriate Industrial Technology (ID/WG.309/6), September 1979.

number of sources of information and serve users in all developing countries, its work presents great potentialities for developing international co-operation and could well form the nucleus of a technology bank with wider objectives and functions.

A concept of human resource development that would act as a framework for strengthening the technological capabilities of developing countries should be elaborated through specific programmes of action. Within such a framework the training activities of UNIDO in the industrial and technological fields will have to be intensified. Training programmes for upgrading specialized skills should cater to a variety of personnel such as skilled workers, industrial engineers, production engineers and managers. The skills to be upgraded include those pertaining to the production process and also to other technological functions including information, technology acquisition, technology planning and policy co-ordination, innovation, R and D, and all aspects of policy-making in relation to technology, in other words, the whole spectrum of the process of development and transfer of technology. Special attention should be paid to the promotion of engineering and consultancy services, technological delivery systems, industrial extension services etc.

Efforts to develop new technologies should concentrate on certain areas that will make the maximum contribution to the achievement of technological self-reliance in critical sectors. For certain developing countries this will mean the upgrading of technologies in the processing of materials for export and in adding further value to them. A measure of contribution to industrial output could be obtained from the rural areas if technologies suitable to them are identified or developed and applied. This will also have the effect of industrial dispersal and the expansion of the market. The development of technologies should be based on the application of the results of modern science and technology. For this purpose technological advances should be continually monitored. Attention should also be paid to the identification and development of alternative technologies in the field of energy, in view of the close interrelationship between energy and industrialization and the energy constraints that several developing countries may face.

The role that UNIDO could play in the promotion of technological co-operation among developing countries can best be summarized by the recommendations of the Round Table Ministerial Meeting of Industrial and Technical Co-operation among Developing Countries, referred to earlier.

"1. An information system should be set up that would concentrate on the kinds of information that could broaden the possibilities of co-operation among the developing countries, i.e. information on: (a) the availability of appropriate technologies; (b) the terms of licence or collaboration agreements concluded by developing countries; and (c) the availability of skilled manpower and expertise in various countries.

"2. In consultation with Governments, UNIDO should explore the possibility of expanding and strengthening already established R and D institutions in developing countries to make them 'centres of excellence' in specific technical fields and prepare a detailed study of the subject.

"3. UNIDO should review possible constraints, both internal and external, that may affect the setting up of joint industrial projects and market-sharing arrangements.

"4. UNIDO should initiate studies to identify ways of co-operation in the following sectors of industry:

Chemicals
Engineering
Electronics
Energy
Fertilizers and agro-chemicals
Pharmaceuticals

"5. Under the auspices of UNIDO, concrete programmes through which the relatively more developed of the developing countries could assist the least developed countries should be formulated and implemented.

"6. UNIDO should convene round-table ministerial meetings periodically, to be held in developing countries in different regions in co-operation with the host country.

"7. UNIDO should outline projects of co-operation and submit them for consideration to the developing countries. A committee of experts should work out guidelines for collective action" (UNIDO/IOD.133).

The Declaration of the Istanbul Round-Table Ministerial Meeting on the Promotion of Industrial Co-operation among Developing Countries, held in October 1979, reiterated those tasks of UNIDO, including examination by UNIDO of the possibilities of developing INTIB as the nucleus of a "technology bank" (ID/WG.308/4, p. 21 (q)).

Finally, the technological self-reliance of developing countries can be achieved rapidly only through the promotion of major concepts on which action could be based. The first major concept in this connection is that of technological self-reliance itself. What has been presented in this report is a preliminary view of this concept that will have to be complemented by assessments, at the field level, of the actual experience of developing countries and by promotional measures for the adoption of operational strategies by individual developing countries. UNIDO will endeavour to carry forward this concept to the point of integrated and sustained action at the country level.

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