# CHAPTER V

## DEVELOPMENT AND MANAGEMENT OF TECHNOLOGICAL CHANGE IN INDUSTRY

The contribution of the Industrial Development Unit and an outline of some future perspectives for developing countries

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## I. Technology Transfer in IDU Assisted Projects

Since its inception in 1980/81, the Industrial Development Unit (IDU) has extended technical assistance to Commonwealth developing countries, at their request, in almost forty industrial sub-sectors (see Table 1 on page ). Food processing accounted for the largest single number of projects (over one-fifth of the total), assistance being given to the processing or refining of sugar, vegetable oils,meat, fruit and vegetables, and salt. Non-metallic mineral products (e.g. ceramics, glass, cement and bricks) and metal products (e.g. cans, wire products, sheet metal and other light engineering products) each accounted for 10 per cent of the total, as did projects in the chemicals, textiles, and machinery and transport equipment sectors. Over three-quarters of the projects were in the least developed and small island countries of the Commonwealth and all were small in scale.

The projects have included introducing processes, materials and products new to the recipient countries. IDU has been involved in pre-investment and feasibility studies, selection of technology, joint venture participation, technical services for engineering and plant commissioning, development of entrepreneurship, and transfer of technology and provision of related training.

Technology transfer from Commonwealth sources for development and implementation of projects is a cardinal feature of IDU's catalytic role. Such transfers have been effected through the preparation of engineering drawings or process charts, adaptation of commercial technology,'on-the-job' training, and simulation and testing of engineering models for commercial production according to the needs, skills, resources and markets of host countries.

In the development of seaweed industries in Tonga and Fiji, for instance, the proven R&D expertise of a commercial source in another Commonwealth country was utilised to develop products suitable for the marine resources of these islands. Similarly, for solar salt projects in several Commonwealth countries, IDU drew on specialised engineering expertise in the Commonwealth for designing solar salt pans, and checking brine density. Suction glass forming technology was similarly derived, and adapted for small-scale operations in countries with limited markets for glass products. Commonwealth technology inputs were also critical for the development of ceramic industries in Guyana and Uganda.

In several instances, more complex technologies had to be identified from appropriate sources and transferred to projects on which IDU's assistance was required to ensure commercial viability. Illustrations include the assistance given in developing computer-aided design and manufacture (CAD/CAM) for upgrading small-scale automotive parts manufacturing in India, microelectronics applications for small industries in Malaysia, the electrolysis process for ammonia-based fertilisers in Malawi, and the production of sulphuric acid for detergents in Jamaica.

Table 1

INDUSTRY DISTRIBUTION OF IDU-ASSISTED PROJECTS
1980/81 - 1983/84

| ISIC Group | Industry Sub Sector | No. of Projects |
|---|---|---|
| 01 | Agriculture | 2 |
| 20 | Food processing | 76 |
| 21 | Beverages | 9 |
| 22 | Tobacco processing | 1 |
| 23 | Textiles | 30 |
| 24 | Footwear | 2 |
| 25 | Wood and cork products | 19 |
| 26 | Furniture and fixtures | 4 |
| 27 | Paper and paper products | 13 |
| 28 | Printing and publishing | 2 |
| 29 | Leather and leather/fur products | 14 |
| 30 | Rubber products | 4 |
| 31 | Chemicals and chemical products | 31 |
| 32 | Products of petroleum and oil | - |
| 33 | Non-metallic mineral products | 36 |
| 34 | Basic metal industries | 14 |
| 35 | Metal products | 36 |
| 36 | Machinery (non-electrical) | 8 |
| 37 | Electrical machinery & appliances | 11 |
| 38 | Transport equipment | 13 |
| 39 | Miscellaneous manufacturing industries | 10 |
| | | 335 |

Complex process and instrumentation controls were designed for the sugar industry in Trinidad and Tobago which has also requested assistance in the development of an electronics industry.

Technology and specialised expertise have been used from both developing and developed countries. They include Antigua and Barbuda, Australia, Barbados, Britain, Canada, Cyprus, Guyana, Grenada, India, Jamaica, Malawi, Malaysia, New Zealand, Nigeria, Singapore, Sri Lanka, St.Lucia, Swaziland, Tanzania, and Trinidad and Tobago. R&D institutions in Commonwealth countries have also given advice.

In IDU's future programme approved by Commonwealth Ministers of Industry in August 1984, it is recognised that technology will remain a key input in the implementation of industrial projects in Commonwealth developing countries. This is as true of the provision of basic needs - food, clothing, shelter, energy, transport, health and education - as it is of, say, mining, smelting and engineering.

Most Commonwealth developing countries are seeking to raise their self-reliance in food processing. This is typified by projects directed at, for example, implementing a beef industry (Antigua and Barbuda), undertaking fruit processing (The Gambia and Grenada), refining edible oils (The Gambia and Sierra Leone), and carrying-out fish processing (Kiribati, St.Lucia, Seychelles, Tuvalu and Vanuatu). In clothing, the range of projects to be assisted includes those intended to produce dyestuffs and dyed cotton (Bangladesh), sea island cotton (St.Christopher-Nevis), ready-made garments (Sri Lanka), and footwear and leather products (Botswana, Uganda, Tanzania and Western Samoa). Housing projects include the proposed production of chipboard and PVC tiles in Fiji, clay products in Botswana, and ceramics in Solomon Islands. In energy, assistance will be given to developing solar systems (including photovoltaics) and mini-hydro systems, to energy conservation and management (including evaluation of woodstoves, use of coconut oil in place of diesel oil, and of retrofitting boilers for biomass fuels) and to other projects helping small countries to reduce their dependence on imported energy. The projects include the manufacture of specialised appliances for solar refrigeration, photovoltaic electric lighting and water pumping in Cyprus, Kiribati, Sri Lanka, and Solomon Islands. Assistance in the production of pharmaceuticals to support basic health services is envisaged for Malta, Nigeria, and Swaziland. As regards education, help will be given for paper production in Dominica and Zimbabwe and for colour printing in Tonga. Assistance planned for projects involving high-tech microprocessor controls in the automotive industry in India and Malaysia and an increase in the local content of motor vehicle assembly in Zimbabwe typify efforts directed at the basic needs area of transportation.

Help in the development of mineral industries will be important in several member countries including Barbados, Cyprus and Malaysia. Light engineering industries will be of prime interest to countries such as Malta, Mauritius, and Trinidad and Tobago. Projects for reactivating, upgrading, modernising and expanding existing industries continue to be emphasised by countries such as Jamaica, Uganda, Tanzania, Ghana, Zambia, Nigeria, Kenya and Zimbabwe, which possess relatively developed industrial bases.

## II. Technology for Commercial Projects in Developing Countries

### Criteria for selection

According to the memorandum setting it up, the IDU is required to assist in the development of bankable commercial projects. As in the case of most industrial projects in developing countries, these are financed by development banks and by commercial banks which may insist on internal rates of return of 15 per cent or more. Apart from the need for financial viability, technology selection involves more than choosing the labour-capital proportions of a given process. Labour and capital are not homogeneous production factors, so that not two, but many inputs must be considered. There are many types of capital goods, some serving only one function, but many having alternatives. Skilled labour inputs are human capital. Capital-intensive technologies may not necessarily create less employment than labour-intensive technologies, if the technology uses capital goods manufactured with a high labour content. Furthermore, for a given capital-intensive technology, the rate of savings may be higher than for an alternative labour-intensive technology, given higher marginal rates of saving for private or government owners of capital than for workers or proprietors of small enterprises. As a result, future employment as well as future income may be higher with such technologies. In other words, there may be a trade-off between present and future employment. Factors such as scale, capacity utilisation and plant location also need to be evaluated. Consequently there can be no rigid rules about the types of technology applicable to particular countries.

### Need for scientific and technological capacities

Technology selection in developing countries, as in others, has to take account of new techniques and processes. Advances in a number of fields such as genetic engineering, biotechnology and microelectronics have far-reaching implications on the growth and pattern of industrial production, technology transfers and employment. Many of these advances derive from basic scientific research and are relatively sophisticated, but their industrial applications are relatively simple. According to UNIDO, about two-thirds of the industrial production of developing countries could be affected by these technological advances. Micro-electronics, for example, will have a major impact on the engineering, printing and clothing industries, while biotechnology will impact on the chemical, pharmaceutical, food processing and energy industries.

UNIDO studies stress that high-technology is not an escape route from the problems of development but only a part of the available technology options, which range from the traditional to the advanced. In an interdependent world, the developing countries cannot be left in technological isolation. They ought to have access to all types of technology and not merely to the simpler varieties. The basic technology used in developing countries has to be upgraded. Each country thus will have a combination of technologies that will be optimal in the light of its objectives, problems and constraints, including the skills

and capabilities of its people who are ultimately both the creators and the beneficiaries of technology. Small industries, small energy systems (including mini-hydro units) and agro-industries are some of the areas that could be upgraded through application of advanced technologies. The viable introduction of scaled-down technology is especially relevant for small states and least developed countries where industrial development is particularly difficult because of small markets, meagre resources and scarce skills.

Some developing countries have emerged with a large pool of scientific and technological manpower through the steady process of education and training, and through institution-building such as the establishment of science parks. Most developing countries, however, lack technological services. These 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 injection of technology inputs appropriate to each project has been a key feature of the IDU's work. Such inputs have ranged from the traditional technology of coir weaving, oil milling and furniture making, to the application of microelectronics and specialised technological designs for small-scale projects on a commercially viable and economically efficient basis.

Basic engineering and design capability has been a significant gap in many developing countries, making local control over imported technology packages extremely difficult. In responding to these gaps, IDU undertakes field work in association with local personnel who thus receive some measure of training 'on-the-job'.

Application of advanced technology is seen as a major goal of international cooperation for development in the 1980s and 1990s. By solving problems in the fields of health, water and sanitation, these technologies would enable the benefits of development to reach down to the poorest. 'Technologies for Humanity' could thus become a reality.

Because of the close and dynamic interrelations between industry and technology, it is becoming increasingly apparent that technology should be considered in an integral manner with policies for industry, particularly industrial restructuring, as well as those for energy and human resource development. Technology will remain a key factor in development, and a suitable framework for national action to strengthen technological capabilities and expand the frontiers of international techno logical cooperation is imperative.

In the past, developing countries have been concerned mainly with whether, how and when to import existing technologies, and how to adapt them to local endowments. There has also been concern on how to hold at arms' length the powerful transnational corporations which are the main suppliers of technology, and on how to identify sources of appropriate technology. It is now

equally important to evaluate the impact of new 'heartland' technologies on the world pattern of production and employment, and on the comparative advantage of developing countries in industrial production. Increasingly intense competition from low-cost, high-technology producers will necessitate special assistance for developing country industries if they are to achieve viability.

## III. Trends in World Industry and Implications for Developing Countries' Technology

### Manufacturing output and structural change

Between 1963 and 1980 the developing countries' share of world manufacturing rose (according to UNIDO) from 8.1 to 11 per cent. The annual growth of these countries' manufacturing averaged 8 per cent between 1963 and 1975, and 4.7 per cent between 1975 and 1982. At the same time, the slower growth in output of the industrial market-economy countries meant that their share of the total declined, especially in the case of the United States (the performance of Japan was dynamic throughout). Overall, there was a major transfer of industrial productive capacity away from the traditional suppliers of technology.

Among the developing countries the growth of manufacturing exceeded that of GDP. At the same time, there was a significant transformation in the structure of the manufacturing sector. The main factor in this transformation was the relatively faster growth in production of intermediate and capital goods (machinery, transport equipment, etc.) than of consumer goods: as a result, the share of the intermediate and capital goods sector increased from 48 per cent of the total in 1963 to 62 per cent in 1979. It was caused by a number of factors. They included the enlargement of markets and resource bases as a result of institutional and political developments and of a movement towards increased integration as industrial output increasingly formed linkages with the remainder of the domestic economy. This integration seemed to have occurred almost regardless of the orientation of industrialisation strategies, e.g. import substitution or export promotion. However, the effectiveness of the integration was not always clear.

Between 1963 and 1979 the fastest growing industry in developing countries was electrical machinery (annual growth of 11.4 per cent during 1963-73 and of 10.6 per cent during 1973-1979); and its share of industrial output more than doubled during this period. Production of chemicals, petroleum products, plastics, machinery, and metal products was also buoyant.

In developing countries, productivity growth was higher in heavy industries (especially metals and machinery) than in light industries,and this differential moderated the growth of employment. For example, between 1963 and 1980, the share of employment in the metals and machinery sector grew from 11.6 to 14.1 per cent of total employment in manufacturing, while the share of output grew from 15 to 24 per cent.

Expansion of the capital goods sector has been largely confined to newly industrialising countries (NICs). It has not expanded significantly among other developing countries and in some cases its proportion of industrial output has decreased. Trends in the capital goods sector are especially important as embodied technical progress originates largely within this sector. In no industry is this more true than of microelectronics which has often spearheaded technological innovation, both of products and of processes, as the industrial sector becomes more complex and forms greater linkages.

Microelectronics and development

The introduction of microelectronics has resulted in very rapid strides in product innovation. This bald statement can be variously illustrated. For example, in 1982 it was estimated that up to half the products manufactured in the West German electronics sector could not have been produced five years earlier Costs of semi-conductors declined and sales grew tenfold between 1970 and 1980. This, in turn, led to falling prices of computer equipment and made increasing use of computer controlled manufacturing processes, plant and equipment (including CAD, numerically controlled machine tools and industrial robots).

In its initial stages the electronics sector was boosted primarily by the demand for consumer goods - TV, radio, and high-fidelity recording and reproduction equipment. Such goods were particularly susceptible to relocation from the innovating centres towards sources of low cost labour as material costs fell and the ratio of labour costs to total costs increased. Simplification of manufacturing processes as these products became technologically mature lowered the ratio of skilled to unskilled labour and permitted employment of a relatively unskilled workforce, often female. Intense international competition forced transnational corporations to minimise costs by relocating their production between countries. As a result, the share of Asian developing countries in the production of these goods, which had been negligible in 1966, had by 1979 reached 16 per cent for TV production and 19 per cent for sound recorders.

The extent to which the developing countries which have attracted foreign investment are able to sustain independent technological development depends largely on the degree of transnational corporation control over production and R&D. Currently, only Taiwan and South Korea appear to have been able to move away from dependence on TNC subcontracting, whereas production of electronics goods in countries such as Malaysia, Singapore, Thailand and Philippines has remained predominantly under TNC control. Firms such as Samsung (Korea) and Tatung (Taiwan), which have successfully opened subsidiaries in the UK and USA to produce consumer electronic components and products, require independent control and considerable facilities for technological R&D and distribution. Progress outside the Asian NICs has been slow, but a number of other developing countries, including India and Mexico, have embarked upon relatively ambitious programmes.

### Implications of microelectronics development for the Third World

The emergence of some NICs as major producers of high-technology products has ambiguous implications for other developing countries. On the one hand, these countries provide a model for a form of industrialisation which has had a marked success in creating full employment and raising living standards. On the other hand, it could be argued that because technological gaps are widening, export markets have been preempted, and capital and skilled labour resources are increasingly concentrated, the emergence of these countries has made the prospects for late starters even less promising. But even within these Asian NICs it is not yet clear whether the growth of electronics (and other branches of engineering) will be sustained by independent control, or whether it will be subject to the production, marketing and investment decisions of transnational corporations.

The last question can, in fact, be applied to the engineering sector as a whole. For many developing countries 'engineering' still consists of only a few stages of manufacture, usually including the final stage of assembly. This is in contrast to a mature industry with an integrated structure and different stages of production in close touch with each other, which has been shown to be critical to the technological innovation process. The production of a component, or assembly of a piece of equipment, by relatively unskilled labour working for the subsidiary of a transnational corporation will not of itself give rise to the necessary learning in terms of innovative product or process design. Assistance to support and strengthen initiatives in fledgling engineering industries is of paramount importance. Such assistance may include efforts to attract technology and investments from commercial sources in other countries, both developed and developing, and technical support to the small engineering workshops where new ideas often emerge. If innovation and competitiveness are to be stimulated in Commonwealth developing countries, it is necessary that these countries develop a capacity in the area not only of electronics but of engineering generally.

## IV. IDU Assistance in High-technology Industrialisation: Three Cases

It has often been stressed (e.g. at UNIDO IV) that high-technology options should be a part of the appropriate technology structure of developing countries. These options, which include the application of microelectronics in industry, have been reflected in assistance given by the IDU in several projects. Three of these projects are summarised below.

### CAD/CAM assistance for automotive industry (India)

At the request of the Government of India, IDU is assisting the Automotive Research Association in Poona to set up an advanced technology research and design facility for the Indian automotive industry. IDU responded to the request by designing a project with the following key characteristics. First, the transfer of CAD/CAM know-how to design engineers in the Automotive Research Association of India and the automotive manufacturing companies.

In addition to training these engineers in relevant CAD/CAM techniques, analysis was undertaken of components like the crankshaft, motor chassis, bend gear, axle shaft and engine piston so that tangible benefits could be shown to the participants and the results used in producing these components. Secondly, a telecommunications link was established between computer terminals at the Research Centre in Poona, and an international network in the UK, Belgium and the USA. This link not only delivered the necessary computing power to the Centre but established the technical feasibility of linking developing countries to international networks. This type of networking will play an increasingly important role in information dissemination among developing countries. Thirdly, the practical needs of the automotive industry were assessed and suitable hardware and software identified. Finally, an action plan was developed to assist in setting up a CAD/CAM facility in India. When implemented, the project should allow India to develop advanced technology of a high effectiveness.

Development of electronics industry (Trinidad & Tobago)

As part of its strategy to diversify the country's economic base and to benefit from the Caribbean Basin Initiative, the Government of Trinidad and Tobago decided to accord high priority to the establishment of an electronics sector. It requested the IDU to assist in identifying areas in the manufacture of electronic components and electronic goods that offered the best economic prospects for viable operation in Trinidad and Tobago.

In-house work by the IDU soon revealed that what was needed first was the formulation of a realistic strategy for successful development of this sector, bearing in mind the strengths and weaknesses of the project environment. Trinidad and Tobago has a strong technical base, including the University of the West Indies Engineering Department and two other technical institutes. The Caribbean Industrial Research Institute (CARIRI) has a strong application-oriented electronics department. Initial field-work was undertaken by IDU staff and after discussions with the project authority, the Caribbean Basin Business Centre in Washington, it was agreed with the Government of Trinidad and Tobago that a structured approach would be taken, with a strategy formulation followed by a product identification.

As this project represents the first major initiative undertaken by the Government of Trinidad and Tobago in the development of a high-technology industry, it is vital that the policy formulated be not only innovative but practical. The project seeks to develop specific initiatives and catalytic-actions that the authority and the Government need to take to attract investment from high-technology US companies and to create indigenous manufacturers of electronic goods. Extensive fieldwork is to be undertaken in the USA to assist the Government of Trinidad and Tobago in understanding the locational and other requirements of US companies for setting up a manufacturing unit. This, in turn, would assist in preparing a package to attract US high-technology companies to Trinidad and Tobago. After helping to formulate an implementable strategy, the IDU will identify product areas that offer the greatest scope for domestic manufacture.

Development of electronics industry (Malaysia)

There are in Malaysia many transnational corporations operating in the electronics sector. But if the indigenous technology of the country is to develop in this sector, it is important that mechanisms are created to encourage the diffusion of such technology into a variety of productive enterprises, especially into small-scale units. IDU studied the key sectors of electronics, electrical and metal-working industries in Malaysia, and formulated a strategy for the development of small-scale units in these sectors. In addition it identified several items that could be successfully manufactured in small-scale units, and prepared feasibility reports, including action plans and project profiles, for those items that appeared to be most attractive for immediate production.