Chapter 2

Technology Policy: Principles, Experiences and Prospects

I. INTRODUCTION

2.1 In this chapter we shall endeavour to spell out the policy implications of the analysis of the effects of new technologies made above. However, the question of appropriate policies for the management of technological change cannot adequately be discussed at the level of global generality. Countries vary enormously in their technological capacity and needs because of differences in size, living standards, stocks of scientific and other trained manpower, and resources. Within the Commonwealth 27 out of 49 countries have a population of under one million each; by contrast India has almost 700 million people and almost three million trained scientists and technologists. If we look at economic resources, crudely measured by GNP, which limit the scale of expenditure on R & D, education and training, Ghana has a GNP a little over one per cent of that of Britain, whose economy is in turn less than half the size of Japan's and a seventh that of the United States. Yet ten Commonwealth countries have economies less than or around one per cent of the size of Ghana's. Thus between the United States, on one hand, and a small Caribbean or Pacific island, on the other, there is a size differential of 50,000 or 500,000 to 1. Table 2.1 (at the end of this chapter) illustrates the differences in technological capacity. Furthermore, governments differ very considerably in their goals, priorities and ideology. Clearly, it makes little sense to prescribe identical policies for countries with such widely different characteristics.

2.2 From the table a rough classification can be made into six country groups:

Major developed economies

2.3 These account for most global expenditure on new technology and have most of the high-level scientific and technical manpower. They are usually substantial net exporters of technology in the form of goods, foreign investment or through direct sale. In these countries—the United States, Japan, Germany, France and Britain—a major technological priority is developing an innovative capacity across a variety of emerging technologies. However, even among these large and advanced economies, this process involves drawing heavily on imported as well as indigenous sources of technology (except for the United States and, increasingly, Japan), and recognition of the need for collaboration is reflected in the European 'Esprit' programme. There are also substantially different approaches. The French and Japanese are making maximum use of government-private sector collaboration, and government indicative planning. Others, particularly Britain, are relying more heavily on private sector judgements of risk and are providing support mainly through defence and other contracts and modest direct assistance, as in the British 'Alvey' programme.

Medium or small, open, developed economies

2.4 Many rich countries are, in aggregate, substantial net importers of technology. Relatively small population, in the context of an open economy, is associated with specialisation and a comparative trading advantage in resource-based activities (as in Australia, Canada, Norway) or specific high-value-added manufactures (Sweden, Netherlands, Switzerland, Austria). These countries have become materially rich, but lack a strong technological base. They have made less attempt to formulate technology policy explicitly—given that it is more likely to be reactive than proactive—although the Myers Report in Australia did set out the options for maximising the benefits and minimising the costs of technological change in an essentially open economy context.

Newly industrialising, outward-looking, countries

2.5 In Asia, there are a growing number of newly industrialising countries (NICs) which have achieved rapid economic growth associated with exports of manufactures, utilising labour-intensive technological processes and/or standardised products. Japan pioneered this form of development but has progressed well beyond it, as Singapore and South Korea now appear to be doing. The pattern is becoming established in Thailand and Malaysia, and is now being adopted more widely in low-income Asian countries and elsewhere. Such societies, like small open developed economies, are characterised by a predominant dependence on imported technology. But they have lower living standards and are at an earlier stage of the transition from industrial to post-industrial patterns of employment and social organisation.

2.6 While these countries are at different stages of technological development, there are some commonly expressed priorities. They include:

—gaining access to the best internationally available technologies through developing an information infrastructure and facilitating foreign investment and licensing arrangements;

—using new technologies to strengthen labour-intensive manufacturing activities and, for the more advanced NICs, to upgrade production and develop new capital- and technology-intensive exports; and

—training people to meet the skill demands from export industries, including services and high-tech products as well as traditional goods.

Populous developing countries with substantial technology base

2.7 India and China are important, if somewhat special, cases of countries which are poor in income terms but have a large and diversified technological base, are self-sufficient in many areas of technology and are even exporters of capital goods and trained people. There are some common features with the NICs in Latin America (notably Brazil or Mexico). Indian and, where they are known, Chinese priorities have been in two areas. One has been to build up an indigenous technological capacity across a wide front, especially in relation to food, energy and weaponry, but taking in selected aspects of emerging technologies, mature technologies and village artisan technologies of a traditional kind. A second has been to control, quite severely, access to imported technology where this is deemed 'inappropriate' because it is, relative to indigenous alternatives, labour-saving or exposes domestic substitutes to strong competition. There is, however, growing recognition that even for countries which have developed substantial self-sufficiency in technological terms, considerations of economic efficiency are causing countries to import many technologies rather than develop them independently.

Low-income countries with limited technology base

2.8 In most of sub-Saharan Africa and some other developing countries (Bangladesh, for example), poverty is associated with a high level of dependence on imported technology in almost all non-subsistence sectors and a limited stock of educated and technically trained people. In the case of sub-Saharan Africa, long-term policy objectives also have to be located within a short-term context of extreme economic and social crisis, including widespread hunger and falling per capita incomes. Under such circumstances there are short-term pressures to reduce whatever indigenous R & D is taking place. But the crisis is creating its own technological priorities, particularly the development and diffusion of high-yielding foodgrain seeds appropriate to African climatic conditions, and the rapid development of a local capacity to supply spare parts and basic inputs to industry to mitigate severe bottlenecks. Over a longer time horizon the focus of technology has centred on building up a capacity for evaluating, operating and adapting imported technology, involving controls on the indiscriminate use of imported equipment. Many problems are shared with the next group of countries.

Small, open, developing countries with limited technology base

2.9 Small states, the islands of the Pacific, the Caribbean and the Indian Ocean, have a high degree of dependence on imported technology. For them, technology policy involves the selection of a small number of high priority areas for technology development where the acquisition of local competence is crucial, possible and inexpensive, with a strong emphasis on regional collaboration to spread the overhead costs of R & D, training and education. Where there is reliance on foreign technology, small states can develop a capacity for gathering information, forecasting major technological changes which affect principal export products, selecting appropriate technology imports, bargaining, disaggregating imported technology into 'core' and peripheral elements, and absorbing technical knowledge.

II. A STRATEGY FOR MANAGING TECHNOLOGICAL CHANGE

2.10 All governments require some capacity to forecast, assess and monitor the impact of technological change. While the effects of new technologies have a certain measure of inevitability, many problems and future needs can be anticipated and contingency planning can be carried out. This argument in no way implies a commitment to centralised, bureaucratic, decision-making. It does, however, imply that governments can usefully develop some capability in the following areas.

Technology forecasting

2.11 New technology is a field of rapid change and uncertainty. Even where scientific knowledge has been converted into a practical technology which can work outside of laboratory conditions, the market response to an innovation cannot easily be predicted. Thus, governments cannot forecast with precision the magnitude and direction of technical change. Nonetheless, especially for those countries which are technological followers—i.e. which are not at the frontier of innovation in emerging technologies—it is possible to predict change on the basis of what is already occurring in other countries.

2.12 It is possible, as we have shown in the previous chapter, to see the outline of the threats posed by advances in automation technologies to some labour-intensive manufactured exports from developing countries and by advances in biotechnology and new materials technologies to traditional commodity exports. The adjustment problems posed by these changes, especially for highly specialised economies, can be reduced (or new opportunities created) if they are expected and the necessary plans made. Or to take another instance, a major impediment to the diffusion of many microelectronics applications—information technology in particular—is proving to be the lack of people with the capacity to design and operate systems in which the hardware can be productively employed. Knowing this, developing countries can concentrate scarce resources in training people in 'software' and 'systems' appropriate to their needs.

2.13 There are many ways in which even a limited commitment to technological forecasting can provide a useful input to planning: to create public awareness of impending changes; to help markets to function by providing information; to clarify choices. The advice and direction given to Japanese industry by MITI in the 1950s and 1960s and, latterly, the less direct guidance in the form of 'visions'; Swedish restructuring in the 1970s based on government and industry projections; French 'planification': all represent variants of technology forecasting. These experiences have also pointed to the dangers of governments generating cumulative errors and weakening competitive attitudes among businessmen, and also of the difficulties in assembling data; though the OECD has broadly endorsed the value of such projections in reducing uncertainty in market economies. In developing countries there is less experience of technological forecasting, though such countries as Singapore, South Korea and India appear to be succeeding in different ways in developing a forward-looking capacity. In the case of Singapore, the mechanism in very informal; in India a more structured process is being built involving overall projective planning for technology, sectoral forecasting and plant level forecasting for large enterprises. For countries which are very small the labour resources available are more meagre but could be augmented by collaborative effort on a regional basis and through technical assistance. Indeed, small states, usually dependent on one export product, are in particular need of early warning of technologically-induced changes which affect them.

Technology assessment

2.14 There are many important decisions which have a major bearing on the speed and impact of technical change: public sector contracts for defence, communications, information processing and construction; the choice of imported equipment and services under aid projects; the provision and orientation of secondary and higher education; the scale and approach of support services for farmers and businesspeople; priorities in foreign exchange or credit allocation when these are rationed; approvals for major foreign investments. It is important that the technological implications be assessed, even if they are unintentional.

2.15 Moreover there are important reasons why major decisions involving new technology should be informed by a system of technology assessment which goes beyond the normal accounting or engineering criteria, and which is not left to individual plants, firms or government departments. Technology assessment is necessary:

—where there is a range of options. New technologies which are relatively capital- and import-intensive in a developing country context are likely to be used unless adequate allowance is made for the way in which prices normally undervalue capital and foreign exchange and overvalue labour. Social cost-benefit analysis is a recognised tool of project assessment in these conditions;

—to encompass the wider implications of new technologies. These include the impact on the environment and on working and living conditions, even if they are not necessarily quantifiable; and

—to look at the 'systems' implications of employing new technology. Whether, for example, the administrative structure of public sector agencies is such that the new technology can be efficiently used and maintained, and how much additional training and expatriate labour is required to make the system effective.

2.16 Technology assessment is now being adopted as a necessary activity in several countries; Malaysia, for example, now gives it a substantial role in the economic planning process. A capacity to carry out technology assessment should not imply a process of detailed, time consuming, and bureaucratic regulation. It should apply primarily to major commitments. Nor is great sophistication necessarily required. Indeed it is an activity which should not be confined to large countries with sophisticated planning systems; for a small Pacific or Caribbean island state, a decision to computerise the main bank or to introduce automatic harvesting techniques in the plantations of the major crop has far-reaching implications which merit serious assessment.

Information infrastructure

2.17 Without adequate information on new technologies, technological change will be retarded or distorted; neither market mechanisms nor planning will work efficiently; and both technological forecasting and evaluation will be limited in their usefulness. Many developing countries are particularly disadvantaged in their capacity to benefit from, and adjust to, new technologies because of the lack of information available to medium- and small-scale entrepreneurs, scientists and engineers and state officials. This disadvantage arises from several factors:

—nearly all R & D, innovation and technology monitoring takes place in developed countries;

—technology selection among a vast profusion of inventions and applications is, in itself, a difficult, highly skilled and costly activity;

—much new technology is 'privatised' by large companies and subject to property restrictions;

—even where new technology is not so restricted, it is increasingly subject to user charges as a result of being stored in computer systems rather than being available more cheaply from technical journals; and

—even where information on new technology is made available to large firms, government officials and scientists in a developing country, it may be extremely difficult to disseminate it. The main potential users are small, often scattered, and usually ill-educated farmers, businesspeople and traders in the 'informal economy'.

2.18 For these reasons most developing countries have very weak systems for locating, acquiring, analysing and repackaging scientific and technological information and disseminating it to potential users. Governments can try to upgrade information infrastructure in a variety of ways.

2.19 *First*, much can be done through the collection and dissemination of information in national technology registries, data banks, information and documentation centres and specialised libraries, and by arranging access to external data bases. Governments can also commission studies and support survey missions abroad as well as collect, process and transmit information. Even the administration of Hong Kong, which intervenes sparingly, has set up government offices to help industrialists find new foreign technology. However, firms require very specific kinds of information to assist them in making strategic decisions. Only they possess the expertise to articulate these information needs and to 'filter' what is available according to their specific requirements. Hence they must ultimately carry out a large share of this monitoring effort themselves, either individually or collectively. Such efforts are expensive, however, and here a programme of state subsidies can be used to defray the costs.

2.20 Despite the potential for information gathering, most developing countries have serious deficiencies in this area. Highlighting them and recognising the human resource limitations of most of these countries, a UN report[1] has suggested a collaborative approach, on an international and regional basis, for gathering information in specialised areas of particular concern.

2.21 *Secondly*, the availability of information depends on the terms of technology transfer through foreign investment, licensing, consultancy or other means. This is because much of the most valuable new technology—for example, biotechnology applications in health and agriculture—is subject to property restrictions and is available on terms which reflect a degree of monopoly in supply. Where information gathering can help is in assessing the market conditions affecting suppliers of technology, as these might be an important influence on the type of technology available and the conditions under which it will be offered. A careful survey of technology markets will reveal which firms may be willing to provide the technology on 'good' terms. Many firms in the NICs have successfully monitored markets in this way to strengthen their negotiating position. We shall deal later in more detail with questions of technology transfer and the need for developing countries to have a capability to acquire imported technology on advantageous terms. A related issue is patenting. Whatever advantage patenting may serve in stimulating innovation in industrial countries, its effect in developing countries is invariably to arrest the dissemination of technological information, much of it from abroad.

2.22 *Thirdly*, governments can play a major role in the domestic economy by improving information flows to indigenous small and medium-size entrepreneurs. Government-sponsored extension services have been a critical ingredient in agricultural innovation in developing countries, and have a role too in manufacturing, particularly mechanical engineering, where experienced engineers and production personnel can advise on the use of machines and work organisation. But such advisory and information support services can only work in the context of a general economic climate conducive to risk-taking and in conjunction with an easy availability of technological and other inputs.

Policy coordination

2.23 Societies, and governments, which approach new technology passively and in a piecemeal, uncoordinated, way are likely to achieve the worst of all worlds: the painful adjustment costs without the compensating benefits.

2.24 The minimum contribution which governments can make to engender a more integrated approach to technological change is to try to ensure that its own activities are coordinated and consistent: for example, to ensure that its education and training policies are aligned with the changing needs of agriculture, industry and services; and that there is consistency between trade and domestic competition policies. Whilst different goverents will approach coordination in different ways, we would suggest that there is need for an independent unit within government which can take a wide view of the public interest and report directly to the central decision-making authority: the President, Prime Minister or Cabinet. The machinery is not important in itself—some governments have elaborate structures for technology policy which do little. Rather, what is needed is political acceptance that the management of technological change is a crucial task of governments.

Financing technological change

2.25 Creating a capacity to forecast, assess and monitor the impact of technological change will require financial resources as well as a coordinating unit in government. Equally important is the need for funds, usually on a much larger scale, to effect technological change itself. This involves financing not only R & D and other aspects of technology commercialisation but also the more expensive process of investing in capital equipment that incorporates new technology. Government assistance is often needed both for technology R & D and for diffusion and innovation, and a strategy for managing technological change should include mechanisms to promote each. We consider these issues further, in a later section (paragraphs 2.41–2.43 and 2.44–2.57, respectively).

III. POLICIES TO INCREASE INDIGENOUS TECHNOLOGICAL CAPACITY

Priorities and points of entry

2.26 For all societies, the ability to use new technologies and manage them in accord with social goals depends on the extent of indigenous technological capacity. A comprehensive technological capacity involves mastery of a wide range of new and established technologies. Its acquisition is clearly a long-term and complex process. Most poor countries, and especially the smaller of them, have very little capacity. Faced with a succession of new technologies superimposed on existing mature technologies, they have to make choices as to the most useful point of entry. Choices arise in identifying the relative emphasis which should be placed on acquiring a capacity for basic scientific research, producing the technological hardware, systems design, or diffusion and adaptation of externally acquired technologies.

2.27 The choice clearly has to be based on national needs and then on the costs of different options. For low-income countries in Africa and South Asia, agriculture is likely to be the area of major priority, drawing mainly on the mature technologies and increasingly on biotechnology. The nature of biological science and technology, especially in relation to mature technologies, is such that for many developing countries it is feasible to carry out not just technological diffusion and adaptation but important aspects of basic biological research. In some cases—for example the detailed study of local plant life—such work is essential to the creation of an indigenous capacity.

2.28 But in the case of other technologies—for example microelectronics and its applications in industry and services—a quite different set of considerations apply. There are major barriers to entry in terms of the high cost of R & D and of production in respect of semiconductors, mainframe and mini-computers; arguably, even micro-computers. Except for countries whose domestic markets are very large, and indigenous electronics technology advanced, the cost of protecting the production of indigenous hardware, rather than importing it, is likely to be very considerable. Moreover, the movement in relative prices suggests that, internationally, there is a long-term relative scarcity of software skills and a relative abundance of hardware, implying greater savings from the indigenous development of the former rather than the latter. Nor is it just a question of cost; software is much more user-specific than hardware for components, making it more essential for there to be an indigenous capacity to adapt software to local applications. This is also becoming more feasible as software becomes more compatible as between machines, giving greater scope to independent software firms. Arising from these considerations, the most productive point of entry in the computing industry may be 'systems' integration; that is, combining standard, imported, hardware with software packages adapted to specific end-users' needs. To develop such a capacity, however, would make heavy demands not only on indigenous programming skills but on training to upgrade these skills constantly, and an ability to monitor and analyse trends. Whatever the particular technology, investment in human capital in general—in education and training—will almost certainly be more crucual to developing an indigenous capacity than investment in hardware. To this issue we now turn in more detail.

Education and training

2.29 There is a generally recognised need for high priority to be given to human resource development, through education and training, in order to make effective use of new technologies; but there remain many practical questions of method and emphasis. For example, in certain areas, such as peasant agriculture, a capacity for innovation is related to general literacy allied to vocational experience and entrepreneurial flair. But some areas of modern technology, particularly electronics, depend heavily on formal and specific training. The following major distinctions can be made.

New types of sophisticated skills

2.30 The demand for specific skills will naturally depend on the technology concerned. For example, in biotechnology heavy additional demands will be made in certain areas. They include:

—staff trained in the biological sciences to develop the underlying biological know-how related to local conditions;

—personnel for biotechnology R & D work, including specialised laboratory technicians;

—process engineers for the manufacture of biotechnology products;

—agricultural extension workers, linked to field stations, able to educate potential users of new seed and plant varieties; and

—paramedical staff trained to make best use of preventive medicines, diagnostic agents and new curative drugs.

2.31 The microelectronics revolution also is creating a new set of demands for a skilled workforce. They are giving rise to a need for:

—basic software training for a large number of managers, researchers and operational staff;

—electronics-related course work in higher education—polytechnic and university degree course—to marry traditional professional skills and electronics/software capabilities;

—specialised training for programmers, designers and managers. Systems designers are crucial in developing countries, to allow product development without the need for component design skills, and are essential for effective use of new computing systems. Other aspects required for effective software development include programme and data-base designers, and specialists in operational research and mathematical logic;

—on-the-job training for manual workers who are required to operate electronically controlled devices, so as to equip them with basic skills in programming and logic rather than 'blue collar' craft skills (though these may remain relevant in a modified form); and

—a repair and maintenance capability, the lack of which is extensive in most developing countries and accounts for much underutilisation of plant capacity. The problem is becoming more acute with the replacement of mechanical devices by microprocessors, requiring electronic maintenance.

2.32 This classification of employment training requirements is, of course, merely illustrative and refers only to specific new technologies. Finally, we should emphasise that though the application of these new technologies is creating some bottlenecks in skills, in other cases they may be reducing the demand for traditionally scarce skills (in developing countries, for example, a reduction in the need for specialists to check, control and repair complex machines because of self-diagnostic devices).

Technology awareness and scientific literacy

2.33 A long-term strategy to develop an indigenous technological capacity will rely not only on specific training but on a broad awareness of the possibilities of new technologies and the scientific principles underlying them, starting with the *school system*. Without basic literacy, numeracy and scientific education, technological training is likely to be superficial and ineffective. This implies giving a high priority in the basic syllabus of primary and secondary schools to relevant disciplines, particularly mathematics; ensuring the secondary-school system is able to prepare an adequate number of students for higher education in engineering and natural and agricultural sciences (UNESCO has calculated that as few as 10 per cent of African students are in these disciplines); and introducing familiarisation with computers at an early stage (for example, Singapore has developed learning kits for school-level instruction).

2.34 Technological awareness and an ability to understand technological possibilities and limitations is important among *decision-makers*. These have a need for general and specific training in two respects:

—to apply new technologies to improve the delivery and efficiency of public services; and

—to sensitise personnel to the opportunities for new technologies and the implications of technology choice.

Skills for those outside the formal economy

2.35 An important impact of new technologies will be on illiterate or largely uneducated farmers or artisans and those living on the fringes of urban life in the informal sector. This impact could often be made more positive through 'blending' new technology with traditional methods, as we have discussed above. The process of 'blending' requires some degree of 'training by doing'—through demonstration projects and extension work. There is also more demand for vocational training of the type developed in India by the Small-scale Research and Development Organisation to train rural youth as—for example—cycle mechanics and fitters. Since innovation involves entrepreneurial as well as technical decisions, an important additional element in training for small businesspeople and farmers is of basic business skills: book-keeping, for example.

Using technology to teach technology

2.36 The training and education requirements to adapt to new technologies are so great that it is difficult to see traditional teaching and training methods being adequate. New information technology, however, provides the means to teach and train as well as being a subject in which to be taught and trained. Satellite communications now extend the teaching of basic literacy, preventive health and agricultural methods by beaming television pictures into remote villages in India; vocational training programmes for nomadic pastoralists in Botswana make use of micro-computers for clerical and management purposes and for communicating basic business and craft skills. Where new teaching methods can be made cost-effective and the software skills acquired to operate them efficiently, there is a dual advantage of simultaneously teaching and training while raising awareness of the potential of new technologies.

Retaining scientific and technical workers

2.37 Increasing the supply of educated and trained people is only one step; another is retaining them. A dilemma particularly for developing countries (though it is more general) is that if resources are put into scientific and technical education, especially at graduate level, there is a danger that these will be lost. This can occur as a result either of emigration—the 'brain drain'—or of diversion to more personally satisfying or lucrative activities, in administration for example. Emigration is a particular danger where extensive overseas training and education occurs. Misdirection of workers will be common where the economy fails to expand rapidly enough to absorb trained personnel. The crisis in African development, for example, has had a particularly severe impact on the funding and morale of research and higher education institutions. A UNESCO study has shown that in Africa, out of 1,200 qualified research scientists, only 9 per cent are now employed in scientific and technical jobs. The solutions to these problems are clearly complex and long term but, unless there are economic inducements and professional incentives in the form of freedom to carry out research and publish the results, the mere creation of more trained personnel may be offset by a loss of others more experienced.

Who pays?

2.38 Before leaving the question of training and education the issue needs to be raised of 'who pays?'. While there may be a general long-term national interest in acquiring a labour force trained and educated to use new technologies, the short-term beneficiaries are the trainees themselves—a relatively privileged group in most societies—and the companies who employ them. While there are complex issues of educational and economic policy involved, several general points might be borne in mind:

—any transfer of high-technology 'hardware' from abroad in the form of equipment or direct investment should be accompanied by an obligation to train, or finance the training of, local nationals in the vocational skills needed to operate, adapt and otherwise improve the hardware;

—much training can be managed using what is now called the 'driving test' principle; that is, the government sets standards and carries out examination and testing, while the private sector undertakes the training on a competitive basis;

—state supported vocational training can be financed through a cess or levy on beneficiary companies, based on their turnover or workforce, so that those which derive the greatest net benefit will make the greatest commitment to train their staff; and

—few, if any, developing country governments, and only some in developed countries, can afford free education at secondary or higher levels. The system of fees and/or loans which is then required can be used to discriminate actively in favour of disciplines needed to develop a scientific and technological capacity.

Indigenous research and development

2.39 Research and development can be carried out formally, in laboratories, or—of great and underestimated importance—by small-scale adaptations in the field. There are certain areas which appear to be urgently in need of more R & D, of both kinds, in developing countries:

—adaptations to existing technologies through 'blending' or other improvements which involve capital stretching, and reducing the optimum scale;

—improvements in tropical foodgrains such as sorghum, millet and maize, pulses, and root crops such as cassava;

—developments in biotechnology, especially the accumulation of location-specific biological knowledge; vaccines against tropical diseases; protein-rich food sources; alternative sources of energy; new uses for traditional raw materials; and

—utilisation of marine resources.

2.40 There are well-documented cases of successful research which have led to innovation on a significant scale in developing countries: the progress of India's research laboratories in utilising low-grade coal and metallic ores, in upgrading the leather industry, and in developing a multipurpose food additive; the use of indigenous plants in Mexico; ethanol-powered motor vehicles using sugar cane in Brazil; small-scale cement, paper and chemical plants in a variety of countries; biogas production; new construction technologies; solar pumps, wind-powered generators—and many others.

2.41 The central problem for developing countries is that very limited funding is available for indigenous R & D. In particular, despite the value of agricultural research, a survey of over 50 developing countries showed that they spent on this less that 0.5 per cent of the value of agricultural output—as against one to two per cent of much higher output in developed countries. There is, moreover, likely to be only a limited contribution from the domestic private sector; even in the handful of exceptions, like India, South Korea or Brazil, where indigenous enterprises are reasonably well developed, their interests are primarily concerned with R & D on industrial technologies. There is always a danger in these circumstances that the few public resources that are available are spread too thinly and misdirected.

2.42 There is not a great deal that can be done in the short run to narrow the massive disparities between developed and developing countries in relation to R & D expenditure (see Table 2.1 at the end of the chapter). As a rough rule of thumb, UNCSTD set a minimum target of one per cent of GNP for developing countries to spend on R & D by the end of the 1980s, though they are very far from reaching that level. The only advantage which developing countries have as a result of lagging so far behind in R & D expenditure is the opportunity for 'leapfrogging' as a result of acquiring the results of existing R & D. But there has also been criticism that even the R & D which developing countries do undertake produces little of commercial value, and that their research institutions are not particularly effective. Surveys of research centres[2] have found that, in general, those in developing countries are strongly influenced by orientations in developed countries and do not undertake activities relevant to domestic problems; that coordination is usually poor, both nationally and internationally; researchers, especially in practical applications, have little security, low status and low pay; monitoring and evaluation are negligible; and there are constant operating problems because of inadequately trained support staff, shortages, lack of maintenance, and mismanagement.

2.43 Thus, a paradoxical and unhappy situation exists where the potential areas of useful and original R & D which could be conducted in developing countries far exceed the resources available to almost all of them, but where there is considerable dissatisfaction that the R & D carried out fails to meet expectations. A variety of remedies can be tried:

—stricter priorities for the work of public sector institutions. These should be based on felt needs and could be defined by a national advisory body on science and technology or by sector-specific bodies. The dangers of centralisation, however, have to be borne in mind, notably the threat to creativity and independence;

—collaboration. Much successful R & D depends on having teams of disparate skills built up over a period of time. This may require a substantial scale and reliable funding. Many of the problems arising for small-scale, under-funded, research could be resolved through greater collaboration between research institutions in different centres;

—a mandate to most government-sponsored research institutions (including university departments) to concentrate on development work in priority areas. These areas also should be based on felt needs and may include items which, at first sight, seem minor and pedestrian: research into methods of maintenance and repair, local manufacture of spare parts, food preservation to reduce wastage;

—a system of regular, outside, evaluation of public research agencies, including inter-country evaluation drawing on successful 'model' institutions elsewhere. In developing the concept of 'model' institutions, however, what may be required are those which are not copies, with minor variants, of developed country institutions but, rather, bodies with radically different goals;

—insistence on a high proportion of contract research (though not necessarily on a profit-maximising basis, as when the clients are small farmers, artisans, informal-sector manufacturers and poor householders); and

—encouraging in-house work in private firms through, *inter alia*, tax concessions. In India, for example, in-house R & D expenditure has risen almost ten times in the last decade and now involves almost 700 industrial units, encouraged by a variety of fiscal reliefs including a direct tax concession of 100 per cent of current R & D expenditures. In Malaysia, the breakthrough in cloning technology as applied to oil palm and coconut palm has also been achieved by private sector R & D.

Developing links between R & D and production: technology diffusion and innovation

2.44 Even if laboratory work is of high quality, relevant and on a substantial scale, there is frequently a breakdown in the linkage between R & D and production; that is, there is a failure of innovation rather than of invention. There are two areas of policy which might remedy this deficiency.

Assistance for technological diffusion

2.45 Where new technologies are available there may be difficulties in transferring them to small-scale users because of deficiencies in credit, organisation and marketing. It is, for example, possible to envisage many low cost applications of microelectronics in the health, education, energy and food sectors of developing countries. But, although the costs of the hardware may be low and falling, the packages and peripherals are still expensive. In this sense, microelectronics has much in common with the high-yielding seed varieties of the 'green revolution'. It is information-intensive, technologically sophisticated and, though cheap in itself, highly dependent on costly auxiliaries such as sensors, software and peripherals to be truly effective (just as 'green revolution' seeds need complementary irrigation and fertilizers). For these reasons, though the total investment costs of new technology may not be particularly large, they may be too high for the manufacturer in the informal sector of developing countries or for the subsistence farmer. Thus new technology—and the associated improvements in productivity—may be restricted to large firms and large farmers, especially in the early years when it is relatively more expensive, unless there are facilities to share the scale-intensive services and equipment.

2.46 There are many ways in which governments can catalyse private sector activity among small firms. They can:

—provide or promote special credit schemes for small farmers and businesspeople whose needs have been neglected by banks. This is especially important where small-scale users cannot afford even those new technologies which have been designed for them through 'blending';

—sponsor the extension services which have been a critical ingredient in agricultural innovation in developing countries;

—provide experienced engineers and production personnel to advise on the use of machines and the organisation of work in the manufacturing sector (as in South Korea); and

—support the establishment of engineering consultancy services to advise on the choice of technology, make project reports, provide management and training (as with Engineers India Ltd.), and operate turnkey plant. Such services are often crucial to making linkages between R & D and local industry.

2.47 It has to be recognised, however, that government extension and support services often have the same problems of ineffectiveness, low status and lack of competence as have R & D institutes. The best vehicle for diffusing technology may well be non-government institutions; if private initiative is not forthcoming, then cooperatives and voluntary, non-profit, local associations may be needed. These can be helped to operate through acquiring access to credit. But where these institutions are weak, responsibility will fall on governments. Sensitivity to user needs could be achieved if technology centres were established and equipped with R & D facilities—or testing systems, or computer programming facilities—that could be leased. Firms would then be able to develop experience in dealing with or using new technologies without undertaking the risks of ownership. Staff at such centres could be seconded, with private sector personnel moving in and out even at the more senior positions. This would remove some of the problems of bureaucratisation and inflexibility that can arise in public institutions.

Creating a climate for innovation

2.48 Technological change is closely related to investment. Education, training and R & D will not produce significant returns to society until the adoption and diffusion of new technologies is made possible through new investment. Creating a suitable climate for innovation, therefore, requires creating economic conditions for risk-taking and investment, while simultaneously drawing on a strong infrastructure of research and training. For many developed countries this is difficult enough to achieve. For most developing countries, especially small states, which have a very limited technical infrastructure and, often, severe economic problems stemming from external shocks, it is even more difficult. The policy implications can be broken down into more specific elements.

Venture capital

2.49 For countries without fully developed capital markets, there is a need to attend to the problem of venture capital. This has been identified as a barrier to technological advance in many developed countries (such as Britain and Australia) as well as in developing countries. Many governments have encouraged banks or created special agencies to give credit lines or equity for R & D and related commercial activities. However, in practice, these credit lines often prove ineffective, unless they are concurrently supported by suitable under-writing or loss-insurance schemes. They can also be costly to the public purse. Credit control and preferential credit is also being used—as in India—to introduce a variety of technology-related criteria into the policies and procedures for evaluating loan applications by financial institutions. An entirely different approach to venture capital, favoured in the United States, is to give no special considerations but to impose low taxes, so giving an incentive to successful innovation rather than to innovation *per se*.

Competition and monopoly policy

2.50 Governments are pulled in two directions. Innovators would like their risks to be reduced by operating in a sheltered monopoly environment; there are, however, broader grounds of public interest favouring freer competition. In most developing countries the choice is often more painful, since the resistance to innovation may be greater than in developed countries while the dangers of monopoly control, especially by large foreign firms, are also greater.

2.51 A particular focus of attention is *patents* policy, which systematically protects innovators from competition until the technology has been profitably developed; *trade marks* have a similar role in relation to product design. As developing countries develop more technology indigenously, pressure grows for legislation to protect the property rights of private innovators. A balance has to be struck between granting an adequate period of protection while not, in so doing, inhibiting the diffusion of technology, especially in such socially sensitive areas as food and medicine.

2.52 Considerable care needs to be exercised in this area, however. In countries where indigenous innovation is weak and foreign enterprises are strong, local law is often used to protect the patents of foreign companies. This is of particular concern in biotechnology where there is a trend towards privatisation of knowledge under the control of a relatively small number of multinational pharmaceutical and petrochemical companies, so locking users into a 'package' of seeds and associated inputs (such as fertilizers and insecticides). It requires multilateral action for developing countries to obtain easier access to new technology patented in developed countries; but developing countries' own patent laws, covering, for example, new plant varieties and new products, processes and life forms developed through biotechnology, can compound restrictions on access to technology. Domestic innovators can be more effectively rewarded in other ways—through fiscal incentives or preferential purchases by government corporations.

2.53 A further instrument for promoting technological capacity is the use of *mandatory standards*, particularly for materials and components. Mandatory standards can stimulate improvements in the quality of products, especially where they and their associated testing procedures are made progressively more stringent over time. But, again, considerable care needs to be exercised. Standards can easily be used to impose international levels of finish and packaging so as to protect the products of foreign enterprises from competition by local firms which are making genuine innovations, using local materials, and producing at competitive prices.

Tax incentives

2.54 Incentives for technological innovation can be supplied by *fiscal policy*. Concessions and exemptions from both direct and indirect taxation have advantages over other instruments—such as grants or subsidies to particular firms, or state managed R & D—because they minimise bureaucracy, avoid the need for invidious distinctions between firms, are stable and predictable, and reward success. Singapore, for example, has used tax holidays, generous tax deductions and accelerated depreciation allowances to attract substantial investment in high-technology activities. Fiscal incentives, however, have the disadvantage of providing costly benefits to many firms which do not need them. They can be made selective, though for this to be effective needs a capacity for making economically efficient choices. Some governments—such as those of Japan and South Korea—seem to be able to do this, but many do not.

Macro- and micro-economic policy

2.55 General economic policy and performance are undoubtedly crucial to the climate for innovation using new technologies. At a *macro level*, innovation is more likely to occur in conditions of economic expansion. The process is circular. In some countries, such as Japan, and South Korea and the other Asian NICs with rapid growth in exports and domestic sales, new investment pays off rapidly. Rapid expansion feeds favourable expectations among entrepreneurs. The introduction of new technology is frequently profitable and profits finance new investment, more R & D and innovation. Rising consumer spending creates new demands. And as some economies, including the NICs, push against the frontier of full employment, there is a further stimulus to process innovation.

2.56 The opposite case is one of recession and slow growth, especially if accompanied by inflation which blunts the awareness of genuinely viable innovations. These conditions have been experienced to some degree in Western Europe; very acutely in Latin America, where 'adjustment' policies have caused substantial falls in per capita income; and most seriously of all in the prolonged crisis being experienced in sub-Saharan Africa. In each of these contexts one of the consequences of attempts to maintain current living standards has been a cutback in investment. In the most extremely affected countries, especially in sub-Saharan Africa, scientific and technological capabilities are also being cut back drastically in order to given precedence to debt service and to food and energy imports. The position of technological development in many of these countries borders on the desperate, with serious setbacks to research, insufficient services and investment of all kinds. The resolution of the wider economic problems is no part of the remit of this Report, but it needs to be underlined that every effort should be made in conditions of crisis to protect the technological and scientific infrastructure on which long-term growth depends.

2.57 There are also economic policy issues at the *micro level.* Deficiencies in technological development in many developing countries can be explained in large part by distortions in specific labour, capital and foreign exchange markets. For example, overvalued exchange rates not only make exports and import-competing activities unprofitable, but frequently lead to exchange control under which arbitrary decisions to allocate foreign exchange for particular items of high-technology hardware or software can wreak havoc with attempts to create a rational technology policy. Measures to rationalise markets so that prices reflect scarcity can clearly alleviate these problems. A similar remedy can stimulate technological innovation and more intensive use of new technologies in energy and agriculture. The 'green revolution' has progressed fastest where government research, extension and distribution services have been complemented by ample price incentives to farmers as well as by cheap agricultural inputs.

Support for indigenous new technology products

2.58 For countries with a large domestic market, there may be the option of developing a capital goods industry and, in the case of microelectronics technology, of building up a capacity to make computers of various degrees of sophistication, together with the main components used in them. There are implications both for *trade policy* and for *government procurement policies.*

2.59 Historical experience of *trade policy* does not provide a very clear guide. There are convincing examples of countries which, at least at some stage, made rapid progress economically and technologically behind protective barriers (Japan and Germany), and of others where similar progress took place under free trading conditions (some of the smaller OECD countries; more recently Singapore and Hong Kong). The case for a more protective policy is that it is necessary to build up the local industry and especially the capital goods—machinery—sector needed to secure a firm technological base. It is argued that intense competition could inhibit entrepreneurs from experimenting with new technology. The experience of countries such as India, which broadly have protected domestic production (especially of capital goods), is that they have enabled the economy to build up a diverse and fairly sophisticated base in industrial technologies, including exports of capital goods; but the same set of policies has also fostered areas of inefficiency and technical backwardness. The trend of policy in the light of this experience is towards import liberalisation and in the particular case of electronics, towards freer, albeit selective, import of capital goods and components.

2.60 In the case of electronics some degree of import management is likely to be necessary even within a generally liberal approach to imports of hardware. For example, if a large number of models are admitted, this will impair the country's ability to develop an efficient local software capacity, especially if systems are incompatible. But too small a number will risk giving overseas suppliers a monopoly position.

2.61 *Government procurement policies* can also be crucial in developing indigenous technology. In many sectors, the government usually accounts for most of the domestic market: military equipment; civil aircraft; telecommunications; pharmaceuticals; power plant; some branches of civil construction—roads, railways, ports and airfields. Typically also, governments probably account for more than half of the aggregate market for electronics products. While in some developed countries, procurement—especially of defence equipment—is used consciously as a means of stimulating technical innovation, in many developing countries the reverse may apply. In these countries the availability of 'cheap' equipment under aid programmes, and the greater ability of multinational companies to comply with formal tender requirements and procedures, may induce a bias against domestic firms. This can be combated in various ways:

- —governments can give local firms an opportunity to compete for supply contracts on a preferential basis or reserve contracts for them. This gives the local firms a secure market, reduces their risk and creates a learning opportunity;
- —the public sector can encourage local firms to achieve international quality and cost standards through the use of component/equipment performance requirements;

—publicly stated procurement policies which favour local firms can be used to alter existing relationships with foreign suppliers of technology, forcing the latter to make more effective technology transfers; and

—governments can insist on a full appraisal of alternative technologies, using a comprehensive social cost-benefit framework rather than narrow commercial criteria. In this way, 'appropriate', if unconventional, technologies can if necessary be brought within the purview of decision-makers.

2.62 It needs to be remembered, however, that the effects of government preference for local suppliers are much the same as those of import controls. There are costs (to public sector consumers and the budget) as well as benefits, and there is a danger of creating uncompetitive, undynamic enterprises dependent on government patronage.

IV. MANAGING TECHNOLOGY FOR SOCIAL NEEDS

2.63 The broad consensus required to mobilise support for economic and social adjustment to accommodate technological change will only occur if the benefits of that change are tangible for most sectors of the population. The benefits of new technologies will be apparent principally in the form of rising living standards. Immediate gains will be felt in the form of new or higher quality products and lower (real) prices for existing products. However, there are important respects in which the commercial innovation of technology, and market adjustment, will fail to meet social needs, even if they satisfy private demand:

—where the majority of the population have low incomes and play little or no role in the money economy, as in many developing countries. The products of new technology, being designed primarily for middle- and high-income consumers, may be irrelevant to their needs (and possible harmful); and

—where new technologies have implications for aspects of life which go well beyond the purely technological and economic: the environment; official secrecy and individual privacy; national security.

Technology for basic needs

2.64 While technology policy cannot, by itself, rectify major inequalities of income and opportunity, governments can try to correct the bias in technological innovation favouring the tastes only of middle- and high-income consumers in developing countries and of consumers in developed countries generally. There are, for example, new technologies which can be developed, and their diffusion encouraged, which reduce the cost of necessities and the insecurity and drudgery of life of low-income groups. They include those directed towards:

—cheap energy for rural households and small farms being developed through biogas and, on a smaller scale, windmills and solar power;

—drought- and pest-resistant, high-yielding, strains of foodgrains, especially those such as cassava, which are indigenous to low-income countries;

—improved health services making use of new vaccines and drugs developed through advances in biotechnology and of micro-computers for survey work, clerical tasks and management purposes. China is reportedly far advanced in combining indigenous low-technology with sophisticated imported technology;

—television-based mass literacy campaigns, combined with informal education, as are being carried out in India;

—low-cost construction, water supply and sewage disposal techniques;

—remote-sensing to evaluate water resources;

—improved low-cost transportation (bullock carts, cycle rickshaws) and cheap all-weather, feeder, road construction for rural areas; and

—disaster warning systems based on satellite detection.

The above list is merely illustrative. It might be expanded to include items which, while not specifically used by low-income groups, are important basic services: for example, using advanced communication systems to develop an efficient telephone service.

Technology assessment and wider social impacts

2.65 There is a high degree of consensus that technology should be evaluated and managed according to wider criteria than those of technologists and economists. Among the other criteria is the *environmental* impact.

2.66 We have seen how new technologies can assist in environmental protection and ecological conservation; the use of biotechnology to maintain a better genetic balance in forest, animal and plant life, to recycle waste, and develop forms of agriculture which make less use of land; the development of new energy technologies which reduce dependence on fossil fuels and nuclear power; the application of satellite tracking to monitor forest depletion, land erosion, and over-use of water supplies. But there are also dangers to the environment, to the air and water from pollutants and to the land from the application of new chemicals (for example long-term consequences of excessive nutrients in conjunction with high-yielding seeds).

2.67 Among the many ways in which governments can act to minimise any deleterious side-effects of new technologies on the environment are:

—to enact and enforce national and international legislation regarding environmental pollution. In particular action is necessary to control the use of modern technologies where there is a danger of serious damage to ecological systems beyond the immediate area of application (for example, acid rain, fluorocarbons);

—to enact and enforce policies relating to natural resource conservation, particularly forests;

—to make efforts to substitute non-renewable resources, both minerals and energy, by renewable ones and to conserve the rate of consumption of selected non-renewable resources; and

—to enact the necessary legislative and other administrative mechanisms to promote the culture of recycling and utilisation of 'waste' materials of all kinds. In some cases, notably the disposal of nuclear waste, new legislation may be required.

2.68 Another element in technology assessment would have to be the *health and safety* impact. A new generation of products and processes is emerging whose properties and long-term consequences are very imperfectly understood. The ramifications are immense, but two policy priorities should be stressed. There should be:

—greater research and monitoring by independent bodies of the side-effects and control of potentially dangerous substances and processes. This is especially true of the new biotechnologies where barriers to entry are often low, but where there is emerging a higher degree of secrecy and limitations on access to property information; and

—creation of at least a minimum 'critical mass' of health, safety and consumer protection officials, particularly in developing countries, independent of both the corporate sector and those sections of government with an interest in promoting new technology.

2.69 Yet another area of concern is the way in which the revolution in information processing can be abused to encroach upon *privacy*. The problem is complex and involves preventing the invasion of individual privacy by control and surveillance techniques which are still evolving, while also granting individuals' access to official information stored in a large and growing number of ways. Agreement is needed, both nationally and internationally, to define the basic principles for data protection, including transborder data flows, and enact appropriate legislation to ratify the agreements reached. Many governments have already passed legislation but more should consider doing so, while there is also need for greater harmonisation between the various national laws enacted.

2.70 Numerous other ethical, social or political problems are being presented by new technologies: the potential beneficial and malign consequences of genetic engineering and embryo research; the military possibilities for governments, and terrorists, of 'intermediate technology' entering the fields of germ warfare and nuclear weapons. Where public policy can improve upon idle speculation is to support serious technological forecasting and research into the impacts of new technologies.

V. MANAGING ADJUSTMENT TO TECHNOLOGICAL CHANGE

2.71 The concept of adjustment is not new. Since the industrial revolution there has been a continuous process of adjustment to technological change, manifested primarily in the movement of people from the agricultural sector to industry and from a rural to an urban environment. Such adjustment is both a consequence of economic growth and a precondition for it.

2.72 The analysis of the impact of technological change in Chapter 1 pointed to several reasons why it is now necessary to devise policies to assist the process of adjustment:

—there has been a growing awareness in developed countries, especially in Western Europe, that the recent slowdown in economic growth is associated with major 'structural' weaknesses, including reduced job mobility and a slackening pace of technological innovation. A broad consensus has emerged that 'positive adjustment policies' should be adopted;

—technological change, even if beneficial for the majority, may create hardship for particular groups: for example, displaced workers and those living in the neighbourhood of polluting plants. Such an inequitable distribution of costs and benefits needs ameliorative action if technology is to be generally welcomed rather than resisted; and

—the ease of adjustment in one country has implications for others. For example, the growth of protectionism in developed countries, which is a symptom of lack of adjustment, creates serious problems for exporters elsewhere, particularly in developing countries.

Economy-wide policies

2.73 A crucial area influencing the speed and ease of adjustment to technological change is the general conduct of economic policy. Such policy can be designed to engender flexibility and encourage workers and businesspeople to take a stable, long-term, view of their working lives and investments, so that the short-term costs of technological adjustment do not loom overwhelmingly large. There has been a great deal of analysis by the OECD (of developed countries) and by the World Bank (of developing countries) of the economic policies which are most conducive to technological and other adjustment, and we shall here merely summarise their conclusions.

2.74 In the field of *macro-economic* management, price stability, high employment, steady expansion of demand and external equilibrium favour smooth adjustment. By contrast, inflation reduces the capacity and willingness of businesses to invest, restructure and innovate; insecurity created by high unemployment acts as a spur to resist change; and balance of payments crises add uncertainty and instability. But there is a two way relationship between macro-economic and *micro-economic* policies which make use of market incentives. The former will not work satisfactorily without a willingness to change at the micro level by all concerned: for example, labour mobility and a readiness to adapt at the workplace; a willingness by businesspeople to take risks and invest; and competitive markets for goods and services. Yet micro-economic flexibility will often be resisted in adverse macro-economic conditions. Thus there frequently occurs a virtuous circle of flexibility and economic stability or a vicious circle of rigidity and economic instability.

Education policies and adjustment assistance

2.75 A good deal of technological adjustment takes place within enterprises (including those in the public sector) and rests on a framework of dialogue and consent between managers and workers. But much also takes place as a result of changes in patterns of demand and competitive pressures over which an individual firm has little control; so whatever progress can be made in negotiating adjustment to new technology, there is also need for acceptance of wider structural change. Experience, especially in developed countries, has pointed to the importance of the following:

—*school education*. The experience of developed countries has increasingly pointed to the need not only for specific vocational training but also for a broader approach to education—drawing heavily on mathematics, natural science and technology—which lays the foundation for adapting to changing and more sophisticated skill requirements later in life;

—*continuing education.* This is a broader approach to retraining than the narrowly vocational. Its underlining principle is the idea that adults (as well as children) have a right to enjoy further education at stages throughout their career, so as to adapt to future scientific-technical demands;

—*retraining* (and initial training for youth). This is crucial to facilitate technological adjustment at a time of rapid technological change. It calls for substantial and increasing resources from the public sector and incentives for the private sector. Retraining for older workers has however proved to be full of practical difficulties in the absence of an integrated approach involving counselling redundant workers and specially targeted schemes to assisted re-employment;

—*employment programmes.* There is an important role for these programmes specifically targeted to groups such as youth, women and other disadvantaged groups who are considered at particular risk from technologically-induced unemployment (for example, in low-skill activities which are easily replaced by microprocessor applications);

—*redundancy payments.* These can cushion the impact of change on individual workers. In order not to slowdown mobility or discourage investment, redundancy payments can be restructured: first, by society as a whole, rather than employers, accepting part at least of the costs of structural change (in the form of retraining and redundancy payments); and second, by refashioning redundancy payments to act as an incentive for re-employment elsewhere (including self-employment); and

—*pension and housing entitlements.* Pension entitlements are often so rigidly administered as to be a serious barrier to mobility between occupations. They can be made adaptable through comprehensive state, or portable private, pension schemes. Similarly, housing difficulties prevent geographical mobility. This problem can be eased through relocation expenses for displaced workers and greater transferability of entitlements among local authorities.

Most of these policies, however, imply costs for governments, and most developing countries, which lack the resources for comprehensive welfare state provision, are unlikely to be able to provide other than modest adjustment assistance.

Regional policies

2.76 The costs and benefits of new technologies are rarely spread evenly in geographical terms. The growth of electronics-based industries in developed countries has been so far centred on areas where there are concentrations of qualified manpower and satisfactory infrastructure. Similarly the major breakthroughs in developing country foodgrain production based on new technologies has been very unevenly spread. And decline is equally concentrated—in areas of developed countries with traditional labour-intensive industries, such as textiles, or rapidly automating industries, such as vehicles; or in developing countries where technology has reduced the demand for specific commodities. There is now considerable experience, particularly in developed countries, of measures which can mitigate regional decline and disparities in development. Arising from this is a broad consensus that two of the most effective measures in the long term are the provision of *infrastructure* and of *fiscal incentives* which are differentiated regionally.

Labour relations and conditions of work

2.77 A satisfactory system of labour relations, with decisions based on consultation and, where possible, on consensus, will increase the acceptability and, consequently, the speed of technological change. In many cases difficulties which arise in applying new technology can be resolved locally by decentralised bargaining between workers' representatives and employers. Where, for example, new technologies involve the design of new systems of work organisation, participation by employees in the design process is frequently found to be of mutual benefit to employers and workers. Such an approach is inadequate, however, insofar as many of the consequences of technological change occur not as a result of specific actions by the employers of the workers directly affected, but as a result of changes in other enterprises producing competing or complementary goods or services. For this and other reasons, including instances where the government itself is the employer introducing technological change, wider issues of public policy arise.

2.78 As a general rule there should be the earliest possible process of consultation between those implementing the technological changes and those affected by them. This process would not only facilitate the provision of information on the opportunities offered by, and the problems associated with, new technologies, but it would provide a basis for consensus on how the changes should be implemented. Such consultations should involve all those affected: trade unions, where these represent organised workers, together with other relevant groups, such as peasant farmers' cooperatives and consumers' organisations, as well as employers. Governments, too, may well be part of the consultative process. The objective would be to create a climate conducive to decision-making based on a consultative approach to the introduction of new technologies. Such an approach is contained in the ILO's recommendations concerning employment policy, which we reproduce elsewhere in this Report (see Volume II, Appendix 7).

2.79 The great diversity between countries and technologies makes it very difficult to progress from abstract generalities to policy outlines, but a few approaches can be suggested:

—one is to strive for general recognition of the rights of workers to organise to represent their interests, leaving the details of negotiating technological change to specific local circumstances. This approach is primarily relevant to organised wage and salaried employment. Where, as in many developing countries, this accounts for only a small proportion of the working population, additional mechanisms are needed. Ultimately, in some developing countries, the provision of at least minimum rights for workers will depend primarily on governments;

—a complementary approach is to have recourse to generally recognised international norms such as those embodied in the ILO labour statutes. These provide a basis for legal and moral pressure where employers are cavalier in their regard for working conditions; and

—a more novel concept, being pioneered in several countries, is to adopt 'new technology agreements' at the level of the plant, enterprise or industry. Such agreements have been deployed in countries which have made marked technological and economic progress, assisted by good labour relations, but which have been concerned over technologically-induced unemployment. Some of the features of these agreements are likely to find broad acceptance—in particular those relating to training and retraining, and health and safety. We reproduce elsewhere in our Report some possible ingredients of such agreements (see Volume II, Appendix 8).

Adjustment policies of particular concern to developing countries

2.80 Many of the above measures arise largely from the problems of adjustment in developed countries. By contrast, the same problems may often be seen as opportunities in developing countries. For example, the 'deskilling' aspects of some new technologies may make it easier to introduce more efficient processes, hitherto impeded by skill bottlenecks. And any reduction in the demand for female labour in urban offices is likely to be seen as outweighed by the need to use new technologies to alleviate the drudgery of women in a rural environment whose life currently revolves around child-bearing, wood collection for fuel, water carrying, and low-productivity subsistence farming. Nonetheless, there are respects in which new technologies present developing countries with problems of adjustment which require a policy response.

Adapting technological processes

2.81 There are well established, indigenous, labour-intensive technologies which face competition from mechanised technologies. The classic case historically has been the replacement in Asia, especially India, of hand-woven textiles by factory-made cloth.

2.82 Emerging technologies could have a similar effect, demolishing traditional occupations at great social cost. But they could coexist with traditional technologies in a complementary fashion. The benefits of such an integration, or 'blending', are that existing production methods, and employment, can be preserved, possibly with enhanced efficiency. Technology 'blends' are more likely to be assimilated, developed and improved, than are wholly alien, large-scale and capital-intensive technologies. Examples which have been demonstrated, at least on an experimental basis, are the use of microprocessors to provide control functions in biogas production (raising productivity in terms of biomass by a factor of five); in testing and quality control for small dairy farmers (thereby reducing waste); and in control devices in the highly decentralised Italian textile industry, to reduce faults and waste, together with telematics to coordinate outworkers.[3] There are many other possible uses of new technologies in conjunction with traditional activities: micro-computers in agricultural planning; high-yielding seeds in subsistence farming; remote-sensing for water exploration; satellite communications for education in villages. There are, of course, technological limitations on 'blending', and problems of assembling the software services required to make it cost effective. Nonetheless governments can play a useful catalytic role in promoting or undertaking:

—R & D, based on a thorough understanding of traditional as well as emerging technologies;

—centralised training and software services for 'blending' schemes; and

—trial and demonstration projects to encourage adoption by small-scale users.

Product development

2.83 Special diversification programmes can assist countries, or regions within countries, to cope with the decline of activities on which they are almost wholly dependent. New technology is not necessarily inimical to commodity exporting in general, but adjustment problems will arise.

In part, these will have to be met through general economic policies centering on producer incentives; but such incentives may be slow acting in highly specialised economies. Supplementary adjustment measures could include the following:

—joint action by producers (and consumers) to devise early warning indicators of future adjustment problems, to estimate future market demand and to plan accordingly;

—R & D and other assistance to develop new products from the same raw materials (for example fuel alcohol from sugar cane; producer gas from sugar fibre; livestock feed from cane by-products);

—support for the use of new technology processes which improve the yields of existing raw material production costs by, say, reducing wastes (for example bacterial leaching of copper wastes);

—joint ventures with firms from developed countries in production of substitute products; and

—research, advice, credit and marketing support for alternative crops which are agronomically appropriate and economically attractive.

2.84 There are grounds for believing that the broad thrust of new technologies is towards greater economy in raw materials use and, thus, to a general weakening in the market position of commodity exporters. But the position is not universally discouraging. New technologies have the potential to improve the quality of traditional products (for example blending man-made and cotton fibres), or make them cheaper (as in the use of microprocessors to economise on energy inputs), or create new sources of demand (as in Malaysia where it is hoped that current genetic experiments will lead to foreign exchange savings by enabling palm oil to replace diesel fuel).

Manufactured exports and trade policy

2.85 If developing countries diversify their exports from commodities into manufactures they face problems of technological adjustment of a different kind—the advance of labour-saving technologies into those product areas in which low labour costs have been a source of comparative advantage. This raises the question as to whether developing countries should now redefine their trade policies in the light of greater export pessimism.

2.86 Hitherto pessimism has been confounded. The export-oriented NICs have consistently outperformed other developing countries with comparable resources, both in respect of export growth and overall economic performance. While the experience of the NICs is impressive, doubts exist as to whether it can be extrapolated forward to less favourable international conditions which include a combination of slower growth and protectionism in developed countries, as well as the impact of new technologies.

2.87 As far as the NICs themselves are concerned, and the more advanced of the second tier of countries exporting manufactures, there are no strong reasons for doubting the continuing validity of the broad trade strategy they have adopted, provided that—as countries such as South Korea and Singapore recognise—their areas of comparative advantage are viewed dynamically to reflect a growing scarcity of unskilled labour and a rising technological competence and marketing sophistication. There is already evidence that the NICs are successfully diversifying their exports into goods and services by making greater use of skilled labour, and advanced technology.

2.88 A larger question mark hangs over those countries—particularly the low-income developing countries—which are still, predominantly, commodity exporters. When they seek to diversify they face the prospect of being shut out of markets in developed countries by a combination of protectionist barriers and the diffusion of automation in traditional labour-intensive manufactures. So far, at least, these fears have proved exaggerated. Protectionism is a serious problem but is not prohibitive. In such an important sector as clothing—as we discussed in Chapter 1—the diffusion of automation technology has not widely penetrated such processes as sewing and does not yet threaten countries which have a competitive advantage based on the mastery of conventional technologies. Moreover, the market continues to throw up a demand for new products which low-income countries, with low labour costs, are ideally placed to supply; products with individual styling (such as the 'cabbage patch' doll) or complex hand-manufactured operations (the success of Indian handicrafts and cut diamonds, for example); labour-intensive activities which are becoming internationally traded with improved communications technology (printing; knock-down furniture manufacture; software services). And factories using relatively labour-intensive processes also have the advantage of being able to respond more quickly to a sudden increase in demand than do those using much equipment which takes a long time to build, test and commission. If we are to take a long-term view, it seems likely that the growing use by producers in developed countries of automated production methods—and eventually flexible manufacturing systems—will preclude developing countries from building up a comparative advantage in many areas of manufacturing where this could have been expected on the basis of current technologies. But, by the same token, there is every reason for speeding the removal of protectionist barriers in developed countries which exist to defend their industries against 'low-cost' suppliers.

VI. MANAGING IMPORTS OF TECHNOLOGY

2.89 For many developing countries and for most of the smaller developed countries, there will remain a high level of dependence on imported technology. The import of technology, however, can be managed in ways which make it consistent with the objective of developing an indigenous capacity. Government can play a role in this process in several ways:

—the development of an indigenous capacity to adapt new technologies will often necessitate action to ensure that there is a genuine transfer of technology along with hardware and proper attention to the 'systems' implications of imported hardware. This action can include obligations on importers of technological hardware to train nationals, not only to operate equipment but to adapt it, to use local engineering consultants, and in these and other ways to transfer the technology embodied in the machinery; i.e. the 'know-why' as well as the 'know-how';

—it may be necessary to assist domestic purchasers to gain access to the best and most appropriate international technology in a world where there are major gaps in information and many deliberate restrictions on the transfer of technology; and

—where there are small numbers of powerful suppliers and limitations on competition because of the complexity and scale of new technologies, governments in technology-importing countries may need to intervene to improve the terms of technology transfer, both quantitatively (such as prices or royalties) and qualitatively (including the removal of restrictive clauses).

2.90 The international market for technology is complex and imperfect. In general the greater the technological capacity of the importing country the better placed it is likely to be in handling each stage of the technology transfer. There are, in addition, several ways of importing technology which work better in some countries than in others, not least because of the different demands they make on indigenous capacity. Managing technology imports requires making an optimum choice among the options available.

Direct purchase or acquisition

2.91 Much technological know-how is free, or at least freely available in numerous technical and trade journals and manuals, as well as amongst lapsed patents and unpatented inventions. Attempting to acquire technology in this manner may not, however, be an appropriate strategy for poor or very small countries. They often lack the technical and managerial capacity and skilled labour to know where to look for appropriate technologies and how to assess which to buy, let alone use and assimilate. Nor may such a strategy give access to the latest technologies.

2.92 Many owners of new technology are reluctant to sell to potential competitors and thus risk a 'boomerang effect'. But there are exceptions and, in the electronics industry, some enterprises in developing countries have been able to obtain much of their technology royalty-free from component manufacturers, machinery makers and materials suppliers, while some producers of consumer electronics goods have been given the necessary technologies by United States mass-merchandisers seeking to lower their retail prices. Even so, this is an option of limited application which requires a strong base in information collection and other supporting infrastructure.

Purchase of imported hardware

2.93 Technology is embodied in machines and will usually be imported in this form. But a frequent consequence of importing hardware without attention to technology transfer is that there is insufficient associated training and software. Recipient firms get the hardware and some operator training but rarely acquire the underlying know-how and expertise required to improve and adapt the imported techniques. In rare cases (Japan is a good example), a machine or system may be imported once, mastered and thereafter maintained, adapted and replicated domestically. In some other cases, technology is transferred not just in the machinery but also in the setting-up and initial training and management, after which local technological capacity develops enough to continue operations. But more frequently, where technological capacity is limited, machinery is acquired with a continuing dependence on foreign suppliers for operating and maintenance assistance.

2.94 As a result, the performance of imported plants and machines in developing countries often declines over time, whereas that in developed countries normally increases. By striving to maximise the learning component of technology transfer, developing countries have opportunities to develop the capability not only to improve the efficiency of existing plants, but to participate in design and engineering, in the local fabrication of plant and equipment, and often, particularly in the case of the poorer countries, in the development of managerial capabilities.

2.95 In policy terms, this means that governments in importing countries need to develop a capacity to evaluate technology imports, making them conditional upon a training element to provide 'software' and 'systems', and ensuring that technology is 'appropriate' in terms of its technical and economic characteristics. Aid donors also have a responsibility to ensure that any equipment purchased under aid projects is appropriate to local conditions, and is accompanied by technical assistance for project implementation and training where necessary.

2.96 A particular application of the need for a thorough appraisal of technology imports is in the field of computers, particularly micro-computers. There are many pressures leading to their wider use in developing countries. Suppliers of micro-computer hardware and software are actively searching for markets. IBM, for instance, has created an African institute to foster the use of micro-computers as a tool for development. International and bilateral agencies often play a key role in encouraging aid recipients to use computers. Internally, a growing array of government departments are pursuing new technology to create (as they see it) more effective administration, planning and project implementation.

2.97 Given these pressures and potentials, together with the key role of government as a consumer, it is only logical that policies should be developed to guide the introduction and use of imported micro-computers. These policies must start by recognising that the operating environment for micro-computers in developing countries differs greatly from that in the developed countries. In the latter, there is usually a high degree of competence among systems users, local production of hardware and software, available technical support and maintenance, software programmes written in the national language of the user, etc. In developing countries, particularly the poorer among them, almost the opposite prevails. The potential user will be inexperienced, existing programmes of data collection and processing may be inefficient, and decision-making may be highly centralised. In addition the technical environment may be unsuitable: there are often unstable electricity supplies, poor quality transmission lines and climatic factors which can adversely affect the functioning of a computer. Consequently there are numerous examples where micro- and other computers have been introduced into an unsuitable environment and never used properly. However, there have also been major successes, such as the introduction of a network of micro-computers into the Egyptian Health Authority. The successes and failures alike suggest that one of the most important steps is a careful evaluation of the system into which imported technology is to be accommodated—preferably by specialists familiar with the country, rather than by salesmen of the hardware suppliers, as is often the case.

2.98 One of the options to be considered where there is concern to avoid importing 'inappropriate' technology is to import *technology from other developing countries*. Several countries—India, Brazil, Argentina, South Korea, China (Taiwan) and Mexico—have begun to export equipment, turnkey plants and engineering consultancy services; India, for example, exports sugar processing and cement equipment, machine tools and major construction complexes. Technology imported from these countries often has the advantage of being derived from a learning and adaptation process suitable to developing country conditions. One of the dangers of acquiring and mastering less sophisticated and apparently 'appropriate' technology, however, is that in the long run it may be more costly than advanced technology. Thus those developing countries which are learning to operate, adapt and replicate, say, electro-mechanical telephone systems now find that these have been superseded by cheaper and more efficient digital networks.

Foreign investment

2.99 Subsidiaries of TNCs are among the principal agents of technological transfer to developing countries. Many developing countries have liberal policies towards foreign investment based, in part at least, on the access which that investment gives to foreign technology, not only hardware but accompanying 'software'. Others are more selective, encouraging investment only where it is considered indispensable for technology transfer—as in the case of India. Foreign investors are seen as transferring technology directly to their subsidiaries or indirectly in various ways: through backward linkages with local suppliers; by making demands on local firms for enhanced skills to provide maintenance and repair facilities; and by competition with local firms, so compelling the latter to upgrade their skills and standards.

2.100 This particular mode of technology transfer—direct investment—has several attractions: the transfer is usually relatively fast; foreign investment reduces the need for investment in indigenous R & D; the multinational companies have an incentive to ensure that their technology is properly utilised and, where necessary, adapted; and the technological and financial risks fall on the company and not the country. In general these advantages will be perceived more readily in countries at the early stages of industrialisation, when benefits can be derived from mechanisms which combine, in one package, technology with capital, skills, marketing and management. For countries with a greater technological capacity, a more selective 'depackaging'—acquiring the technology in isolation—may have greater attractions, though it is perhaps significant that foreign investment is still a favoured mechanism for sophisticated NICs such as Singapore, and also for countries in Western Europe in relation to US technology. While this is not the place to rehearse the arguments and counter arguments, it suffices to say that some governments have a less positive approach to foreign investment, based on a variety of considerations. These include:

the limitations on technology transfer embodied in many contractual arrangements involving TNCs and their subsidiaries (such as tied purchases or imports; restrictions on imports which threaten the company's other activities; a dependence on expatriates); the perceived inappropriateness of technologies and products; and the disincentive to local innovation when multinationals see their subsidiaries as providing a captive market for obsolete technologies and goods. Suffice it to say that foreign investment may be an invaluable source of transferred technology but by itself will not transfer technology. It is for the government of host countries to ensure, through incentives or restrictions, that training, local R & D, and technology adaptation do take place.

Alternative forms of collaboration with multinational companies

2.101 The costs and benefits of foreign investment can, however, only be meaningfully evaluated when set alongside other feasible options for acquiring technology from multinational companies. Another method for obtaining such technology is *licensing* or some form of *technical cooperation* agreement. The Japanese successfully used the licensing system in the 1960s to import technologies and develop indigenous capabilities without recourse to direct foreign investment. A 'staggered entry' approach was used, permitting one domestic firm at a time to acquire and absorb licensed technology. Other countries, notably India, South Korea and several in Latin America, have also attempted to make use of licensing for technology transfer. But the process of screening and evaluating licensing agreements can have the effect of greatly slowing down the rate of absorption of technology, as appears to be the case in India relative to—say—Brazil, Mexico, China (Taiwan) and South Korea. Moreover, licensing raises the same problems as mentioned above for straight purchasing, namely requiring local expertise as well as financial resources, while it may not provide access to the newer technologies. Studies on Latin America, for example, have found that the use of pure licensing is positively correlated with the maturity of the industry and inversely with patent protection. Direct equity investment, on the other hand, is a more attractive vehicle where complex technologies are involved; and for countries without the resources to negotiate superior alternative arrangements.

2.102 Joint ventures, in which foreign companies help local enterprises to set up production through minority shareholding, are being actively promoted by a number of developing country governments. The latter aim, thereby, to achieve technology transfer from a foreign investor and access to foreign markets without losing indigenous control. Many governments are unsuccessful in this aim, since the foreign companies exercise control despite their minority shareholding. Most successful joint ventures appear to have been restricted to industries producing for the domestic market rather than for export, or in mature industries (textiles, industrial chemicals, non-ferrous metals) rather than in newer ones (computers, pharmaceuticals, etc.). Moreover, there is less likelihood of an effective technology transfer being made than with wholly or majority owned subsidiaries. The proportion of technologies transferred to majority owned affiliates which were 'new' (i.e. less than five years old) rose from 25 per cent in the 1960s to 75 per cent in the 1970s for a sample of chemical, semiconductor and pharmaceutical industries. And according to a survey by ESCAP, the average age of all technologies transferred by multinational companies under joint ventures and licensing was 13 years, while for subsidiaries it was five to eight years. Nonetheless, the joint venture route is being increasingly explored in the Asian NICs. For example, leading South Korean companies are developing technologies, in genetic engineering, fibre-optics, and computer controls, on a joint venture basis with US companies. And in Malaysia a leading plantation company recently teamed up with a leading US biotechnology company to carry out plant genetic engineering in the ASEAN region.

Importing 'know-how' directly

2.103 We have referred above to various modes of technology import which can incorporate training and management (such as foreign investment), and also to other imports (such as machinery) which relate specifically to 'hardware' aspects of technology. For countries which lack the trained people, it may be necessary to import them, if not along with the hardware, then independently. The lower the level of indigenous capacity and the smaller the country, the more likely this is to be necessary. Trained people can be imported through:

—*consultancies*. The use of foreign consultancies in, say, systems design and other technology-intensive activities may be a necessary first step to acquire a domestic capacity. But it would need to be allied to measures to raise local consultancy capability by, *inter alia*, gradually increasing the share of public contract work given to local consultants and the share of project work under aid programmes;

—*management and service contracts*. Where new technology 'hardware' requires complex establishment, operating and maintenance skills, a first step may be to hire management and other skills. The experience with such arrangements, however, is that they are likely to be self-defeating as a mechanism of technology transfer unless remuneration is based on a sliding scale in relation to performance and there is a clear timetable for counterpart training and the gradual phasing-in of local management;

—*education and training abroad.* We have referred earlier to the role which might need to be played by education and training abroad where local facilities are deficient. Consideration needs to be given to solving the well-known problems of: inappropriate specialisation; defective selection; the 'brain-drain' when overseas stays are too long; and the limited communication of education or skills when the stays are too short; and

—*technical assistance.* Aid donors can provide experts at below market rates to perform operational, training or advisory roles incorporating technology transfer. The advantages and pitfalls of technical assistance are too well-known to need rehearsal here, but for countries which require not only imported hardware but the skilled workers to use and adapt it, and lack the resources to buy these skills commercially, technical assistance is indispensable.

2.104 Thus, while indigenous development of the 'software' aspects of new technologies may be the best point of entry for countries to master new technologies, a 'software' capability may itself have to be imported in the first instance, requiring systematic evaluation of the various options.

NOTES*

1. UN, *Study on the long-term plan of action for the establishment of the global information network*, New York: 1985, A/CN. 11/56.
2. For example, M. Ul Haq, 'Wasted Investment in Scientific Resarch', in W. Morehouse, ed., *Science and the Human Condition in India and Pakistan*, New York: Rockefeller University Press, 1968; D. James, 'Scientific and Technological R & D in Developing Countries', in J. Street and D. James, eds., *Technological Progress in Latin America: The Prospects for Overcoming Dependency*, Boulder, Colorado: Westview Press, 1979; and N. Girvan, ed., Science and Technology Policy in the Caribbean, *Social and Economic Studies*, Vol. 28, No. 1, Institute of Social and Economic Research, University of West Indies, Jamaica: 1979.
3. A detailed survey is to be found in James (1984).

* Complete references to the works cited are given in Volume II, Appendix 10, Selected Bibliography.

TABLE 2.1
Characteristics Related to Technological Capacity in Selected Countries

	Categories/ Countries	Population (millions) mid-1983	GNP: Total at market prices (mn. US $) 1983	GNP: Growth rate (per cent) 1973-82	GNP: Per capita US $ 1983
		(1)	(2)	(3)	(4)
I	*Major developed economies*				
	United States	234.5	3,292,340	2.5	14,110
	Japan	119.3	1,204,270	4.3	10,120
	United Kingdom	56.3	505,610	0.9	9,200
	Germany, F.R.	61.4	702,440	2.3	11,430
II	*Medium or small, open developed economies*				
	Canada	24.9	300,400	2.3	12,310
	Australia	15.4	166,230	2.3	11,490
	Sweden**	8.3	103,240	1.1	12,470
	New Zealand	3.2	24,000	0.4	7,730
III	*Newly industrialising outward-looking countries*				
	Hong Kong	5.3	31,900	9.5	6,000
	Korea, South	40.0	80,310	7.2	2,010
	Malaysia†	14.9	27,760	7.4	1,860
	Singapore	2.5	16,560	7.9	6,620
IV	*Populous developing countries with substantial technology base*				
	Mexico	75.0	168,070	6.2	2,240
	India**	733.2	190,710	4.1	260
	China**	1,019.1	301,840	5.7	300
	Brazil	129.7	245,590	5.2	1,880
V	*Low-income countries with limited technology base*				
	Ghana	12.8	3,980	−1.1	310
	Kenya	18.9	6,450	5.0	340
	Sri Lanka	15.4	5,140	4.9	330
	Tanzania	20.8	4,880	3.4	240
	Bangladesh	95.5	12,530	5.7	130
	Nigeria	93.6	71,030	2.0	770
VI	*Small, open developing countries with limited technology base*				
	Jamaica	2.3	2,940	−2.6	1,300
	Mauritius	0.9	1,250	3.9	1,150
	Seychelles	0.07	160	5.1	2,400
	St. Kitts	0.05	40	1.9	820
	Fiji	0.70	1,190	3.1	1,790
	Trinidad & Tobago	1.1	7,870	5.6	6,850
	Tuvalu	0.008	5[a]	n.a.	680[l]
	Samoa, Western	0.16	140[b]	n.a.	870[b]

MRE: Most recent estimate (see facing page for the years concerned).
n.a. Not available.
* Data in columns 5 to 9 exclude law, humanities and education.
** Excluding social sciences and humanities.
† Data refer to peninsular Malaysia only.
‡ Estimates in columns (6) and (8) correspond to the periods indicated in columns (5) and (7) respectively.

Number of scientists and engineers		Number of scientists and engineers in research and development		Research and development expenditure as a % of GNP	Patents in force 1982
Total	As a % of total labour force‡	Total	As a % of total labour force		
MRE					
(5)	(6)	(7)	(8)	(9)	(10)
3,167,000[a]	2.99	660,700[a]	0.62	2.35	1,199,526
4,127,200[a]	6.76	463,062[a]	0.76	2.41	404,293
n.a.	—	86,500[b]	0.33	2.25	228,067
1,981,000[c]	6.73	121,978[c]	0.41	2.40	136,723
537,925[d]	6.28	28,700[a]	0.27	1.24	413,639
231,705[e]	3.98	22,510[e]	0.39	0.72	48,842
335,900[c]	9.21	14,766[c]	0.40	1.88	48,803
47,249[d]	4.31	8,080[c]	0.65	0.85	n.a.
83,200[a]	3.29	n.a.	—	—	n.a.
1,186,416[g]	8.07	20,718[b]	0.15	0.64	8,346
35,415[h]	0.97	n.a.	—	—	n.a.
38,259[g]	4.01	461[b]	0.05	0.15	8,707
n.a.	n.a.	5,896[j]	0.04	0.23[j]	36,659
697,600[f]	0.27	56,527[b]	0.02	0.53	11,992[a]
5,296,000[g]	1.14	n.a.	—	—	n.a.
541,328[h]	1.80	24,015[b]	0.06	0.56	10,953 [c]
6,897[h]	0.21	4,084[e]	0.11	—	922
5,130[j]	0.10	361[j]	0.01	—	1,607
7,457[i]	0.18	604[f]	0.01	0.14	753
n.a.	—	n.a.	—	—	2,079[g]
23,500[k]	0.09	n.a.	—	—	1,071[g]
19,885[h]	0.09	2,200[f]	0.01	0.32	359[j]
5,963[h]	0.95	n.a.	—	—	1,058[c]
6,264[i]	2.44	152[g]	0.04	0.44	189
300[a]	1.03	2[a]	0.01	0.11	44
135[h]	1.04	n.a.	—	—	n.a.
9,734[e]	5.41	n.a.	—	—	14[a]
3,314[h]	0.98	n.a.	—	—	1,900[j]
n.a.	—	n.a.	—	—	n.a.
350[f]	0.92	140[b]	0.37	—	13[a]

[a] 1981; [b] 1978; [c] 1979; [d] 1971; [e] 1976; [f] 1977; [g] 1980; [h] 1970; [i] 1972; [j] 1975; [k] 1973; [l] 1982.

Sources: World Bank, *World Development Report,* 1985; World Bank, *Atlas,* 1985; United Nations, *Statistical Yearbook,* 1982; UNESCO, *Statistical Yearbook,* 1983.