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Katherin Marton* and Rana K. Singh**

New Technologies and Developing Countries: Prospects and Potential

Technological innovations in informatics and other new technologies are having a major impact on most production and service sectors in industrialized countries. Inadequate transfer of such technologies to developing countries, with a few notable exceptions, is increasing the technology gap and reducing competitive capability in these countries. Far-reaching policy changes and a new emphasis on technological development must be made by developing economies in order to avail themselves of the growing potential of new and emerging technologies.

During the last two decades, major technological innovations in electronics and informatics, biotechnology, genetic engineering and new materials, and in fields such as lasers and remote sensing, represent a major and continuing stage of technological innovation and evolution, which are increasingly being applied to a wide range of economic activities. With the continuing technological revolution, new needs and demands are emerging and the structure of production and services is undergoing rapid and significant change in most industrialized economies. Contemporary technologies are both knowledge-intensive and research-intensive and have intersectoral application. There is a close interrelationship and interaction between these technologies, particularly because of the linkages through microelectronics, and the effects of these technologies are likely to be very extensive in various fields of production and services in the next few years. Though these developments have taken place primarily in industrialized economies, their pervasive nature will have a significant effect on all economies, including those of developing countries.

The impact of new technologies on developing countries will comprise not only of reduced demand for

exports from developing countries but also of major changes in the comparative advantage and competitive capability of these countries.¹ One major negative effect of new-materials technology is its impact on exports of commodities, materials and minerals which may be substituted by new materials, ranging from cyclamates to optic fibres, reinforced plastics and composites and high-performance ceramics. The direct impact may be most felt in the replacement or gradual substitution of a basic food product such as sugar and of existing minerals and commodities, such as copper, iron and steel, aluminium, pyrethrum and other such items, by new materials. There has been considerable substitution of sugar by artificial sweeteners such as cyclamates and aspartame, which is likely to result in reduced demand for sugar from developing countries. Similarly, the replacement of copper by optical fibers for communication cables is likely to have a considerable impact on copper-producing countries such as Chile, Zaire and Zambia. There will also be increased substitution and reduced usage of other non-ferrous materials, such as nickel, cobalt and chromium. The steel content in automobiles and transport equipment is also likely to fall considerably because of increased use of composites. Similarly, economies in usage, as well as replacement by new materials, is also likely to take place in capital-goods production, and in various processing and

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¹ United Nations: Impact of New and Emerging Areas of Science and Technology on the Development of Developing Countries, Report to the Intergovernmental Committee for Science and Technology for Development, Geneva 1987.

construction industries, resulting in reduced demand for iron and steel.

Commodity exports from developing countries are also likely to face reduced demand.² Several commodities, such as cotton, natural rubber, sisal etc. are already facing lower global demand because of substitution and reduction in material use. There needs to be adequate awareness of such developments well in time, so that exporting developing countries can undertake alternative programmes. The most significant long-term impact of new technologies, particularly electronics technologies, is likely to be on the manufacturing sector in developing countries and on their ability to compete in global, competitive markets. Electronics technology, especially developments in microelectronics and informatics, is resulting in major innovational developments not only in products but in technological processes and in management techniques. Inadequate technological absorption in this field is likely to result in significant competitive disadvantage. The textile and garment industry, for example, is likely to undergo major restructuring, largely in favour of industrialized countries, because of increased computer-aided designs and manufacture (CAD-CAM). The same would apply to production of a wide range of machinery and other engineering goods, including agricultural equipment and components for transport and other equipment, which also have considerable potential for local production in developing countries. The growing application of CAD-CAM and of flexible manufacturing systems (FMS) and increased automation in various fields of manufacturing, including agro-industries, is likely to place developing countries at considerable disadvantage. There is a growing shift in demand, particularly in industrialized economies, to products and processes involving greater precision and efficiency, requiring greater automation and the use of numerically controlled machine tools and flexible systems for competitive production.³ A similar shift is taking place in some developing countries also, such as Brazil, the Republic of Korea and other South East Asian economies where CAD-CAM operations and use of numerically controlled machine tools and other equipment is increasing. The pace and extent of this increase, however, lags far behind.

Developing countries are also facing a growing technological gap in information processing and

communications. Innovations and developments in telecommunications and data-processing, storage and dissemination, have ushered in a new era of informatics, comprising integration of computers, communications and information technology. The digitalization trends in information transmission networks and the integration of communications services and facilities have greatly enhanced the efficiency of telecommunications and data-processing. The increased usage and local production of informatics equipment has considerable potential in many developing countries, apart from the essential need for keeping pace with developments in communication technologies for access to international databases and information systems and networks.

Transfer of New Technologies

Technology transfer in new technologies has taken place primarily among enterprises in industrialized countries, and has largely been confined to computers, semiconductors and other areas of electronics and telecommunications. The transfer of such technologies to developing countries has, however, been far more limited and is just starting to take place. Till recently, this largely took the form of sales of computers and related equipment, and the offshore manufacture and assembly of electronics components in some countries, particularly in South East Asia, besides the production of consumer electronics products. This has been partly because of the small markets for electronic products in most developing countries, but also because the production and usage of such products has been primarily concentrated in industrialized countries. The advantage of cheap labour in South East Asian countries, however, led to the rapid growth of offshore production and assembly of components by multinational corporate subsidiaries in Hongkong, the Republic of Korea, Singapore, Taiwan, Malaysia, and more recently in Thailand and Indonesia.⁴ The volume of exports of electronic components from these countries to OECD countries rose to over \$ 3 billion by the early 1980s.⁵

The extent of technology transfer in the case of the offshore assembly of electronic components to most South East Asian and other developing countries was very limited but this process generated increased knowledge and awareness of this sector and has led to successful backward and forward linkages, particularly in Taiwan and

² United Nations: *Impact of New and Emerging Technologies on Trade and Development*, Geneva 1987.

³ United Nations: *Transnational Corporations and the Transfer of New and Emerging Technologies to Developing Countries*, Centre on Transnational Corporations, New York 1990.

⁴ R. Kaplinsky: *Electronics-based automation technologies and the onset of systemofacture*, in: *World Development*, 1985, Vol. 13, No. 3.

⁵ C. P. Correa: *Technology Trends Series No. 9: Development in the Field of Informatics in Selected Developing Countries*, United Nations Industrial Development Organisation, Vienna 1989.

the Republic of Korea. Joint ventures and licensing arrangements have also been entered into for production of personal computers and peripheral equipment in several developing countries, including Brazil, China, India, the Republic of Korea, Singapore, Hong Kong and Taiwan. While the smaller South East Asian economies have emerged as major exporters of consumer electronics products, besides semiconductors and other components, production in the larger developing countries is primarily for local markets.

In biotechnology, technology transfer has taken place primarily with respect to high-yielding varieties of crops. Biotech developments, which were formerly in the public domain, are becoming increasingly privatized, through registration of patents and industrial property rights on new developments including with respect to livestock and plants. Biotech developments are of immense value and interest to developing countries, particularly in agriculture and allied industries. So far, there has been little technology transfer, though some multinational corporations are getting involved in biotech production of seeds and vegetables in several developing countries. In the area of new materials, there has hardly been any transfer of technology to developing countries, except for the production of chemicals used in certain new materials.

On the whole, the transfer of new technologies to developing countries has been very limited. It is only in certain South East Asian economies that offshore production of electronics products has initiated rapid growth, and has led to the export-oriented manufacture of a wide range of consumer and industrial electronics products and components, mostly by national companies, including large conglomerates such as Samsung and Daewoo in the Republic of Korea and Acer and Mitac in Taiwan.⁶ In several other developing countries, production of a limited range of consumer electronics products, including telecommunications products and components, has been undertaken, mostly through multinational corporate subsidiaries and joint ventures between such companies in the informatics sector and local companies.⁷

Usage of the New Technologies

A classification can be made of developing countries in terms of applications and usage of new technologies. The first group comprises several countries of South East Asia, particularly Taiwan, the Republic of Korea, Hongkong and Singapore and, to a lesser extent, Malaysia, the

Philippines, Thailand and Indonesia. These countries have adjusted fairly satisfactorily to technological developments in informatics and microelectronics, and have achieved substantial export capability in a number of electronics products, including desktop computers, digital exchanges and major components and subassemblies. In some countries, such as the Republic of Korea and Thailand, considerable research has also been initiated in biotechnology. The second group comprises some of the larger developing countries, including Argentina, Brazil, China, India and Mexico, in which there has also been considerable growth of indigenous electronics production, as well as research in biotechnology. Among these countries, the development of informatics and biotechnology has been the highest in Brazil and a substantial market share of the production of computers and systems is now held by Brazilian owned companies. Despite considerable technological absorption in the other countries, the overall pace of development in new technologies was relatively slow during the 1980s except in Mexico during 1987-90, where there was a considerable inflow of foreign investments and technology in this field. The third group comprises a large number of developing countries, including most other Latin American, Asian and North African countries, in which there has been limited application or development of new technologies in terms of usage or production and research. Finally, the least developed countries, and several island economies and a number of African countries, have not experienced much impact by new technologies, except where offshore production facilities for electronics components have been set up. The above classification suggests that with the exception of certain countries in South East Asia, and some large developing countries, the impact of new technological developments and absorption and adaptation in these fields in developing countries has been very limited.

Policy Implications

Developing countries will need to assess their situation in relation to new, global technological developments and to determine policies and activities which would enable the absorption of new technologies as rapidly as possible. Certain countries in South East Asia are already utilizing electronics and informatics technologies for the production and export of new products. In most developing countries, however, the utilization of informatics and other new technologies has been fairly limited due to a variety of factors, including weak technological infrastructure, non-availability of skilled technical personnel in these fields,

⁶ M. M. Saghaifi, C. S. Davidson: *The New Age of Global Competition in the Semiconductor Industry: Enter the Dragon*, in: *Columbia Journal of World Business*, Winter 1989.

⁷ United Nations: *Transnational Corporations in the Semiconductor Industry*, Centre on Transnational Corporations, New York 1985.

limited resources and difficult overall economic conditions. This is further increasing the technological gap with industrialized economies, and is likely to cause growing concern. Though varying levels of technological pluralism are unavoidable in most developing countries, suitable plans and programmes have to be implemented which would utilize new technologies to meet national needs and priorities and integrate informatics and other contemporary technologies in the process of production, marketing and services in various fields.

Various institutions have been set up and a range of policies implemented in most developing countries for technological development, though these have been related primarily to technical education and varying levels of industrial research.⁸ Despite these measures, however, the technological infrastructure for the application and development of new technologies continues to be very inadequate in most developing countries and needs considerable strengthening in terms of specialized skills

such as computer programming and microbiology, and designs and engineering capability. It is also essential to undertake specific promotional programmes for the development of local production capacity for those new-technology products for which there may be local demand, such as desk-top computers, printed circuits and a wide range of electronic parts and components. In telecommunications, there is a potential for the local manufacture of telephones, besides PBX exchanges and microwave components. The growing field of consumer electronics also presents considerable potential for local manufacture of TV sets, diodes and several other categories of components.

There is, therefore, significant potential for local production of electronics products, ranging from

⁸ International Industrial and Licensing Consultants: Technology Trends Series No. 15: The Changing Technological Scene: Trends in Selected Developing Countries, United Nations Industrial Development Organisation, Vienna 1991.

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INSTITUTIONAL ASPECTS OF ECONOMIC INTEGRATION OF TURKEY INTO THE EUROPEAN COMMUNITY

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In October 1989 a symposium on "Institutional Aspects of the Economic Integration of Turkey into the European Community" took place at the HWWA-Institute. The symposium was conducted in cooperation with the Technical University of Darmstadt and promoted by the Volkswagen Foundation. At the centre of the discussion were the questions of how to strengthen the Turkish institutions responsible for integration and how to make them more efficient, how to evaluate the efforts made by both sides to improve economic relations, and what consequences are to be expected for economic and social policy. This volume contains selected contributions to the symposium and summarizes its results. (Only available in English.)

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consumer to industrial electronics, in several developing countries. This aspect has received comparatively little attention so far except in a few countries, largely because neither local entrepreneurs nor multinational corporations have taken much initiative in this regard. The acquisition of foreign technology for such products should not pose undue difficulty and there are several alternative sources from which such technology can be secured through affiliate relationships, joint ventures or non-affiliate licensing. There are also several medium to large companies in industrialized economies, as also in some developing countries such as Brazil or the Republic of Korea, which may be willing to license technology and know-how to enterprises in other developing countries. The implementation of a well-planned production programme, both for industrial and consumer electronics and in biotechnology, however, requires considerable promotional efforts by governmental and developmental agencies and entrepreneurial initiative on the part of local industrial groups.

Increased Usage and Application

The increased use and development of computers and microelectronics in developing countries needs to be carefully planned. The usage of computers and electronic applications in developing countries has, so far, largely been confined to a few countries and to fields such as office management and service sectors such as banking. The use of computers and other electronic equipment must gradually be extended for greater efficiency and production capability in different fields, and at the same time, production capability has also to be developed with respect to both software and hardware. The nature of such applications will inevitably vary in different country situations but it is essential to develop a strategy for the production of software and such elements of hardware as may be feasible. Several developing countries should be able to develop competitive capability, with respect to both software and peripheral products and components for exports, apart from meeting domestic requirements in different sectors. Capital goods production, which is gradually being expanded in a number of developing countries, should also take new technological developments into full account. There is a need for evaluation and usage for various functions and operations such as office and industrial management, insurance and other financial services, economic models and macroplanning, census and statistical operations and agricultural and industrial activities. There is also

considerable scope for blending electronic applications into traditional sectors, particularly in agricultural operations and in several manufacturing fields, as well as in various services.

The major infrastructural constraints on software and systems capability and on the development of hardware must also be recognized and taken into account. National policies on informatics should, after taking account of such factors and constraints, determine specific norms and standards regarding computers, microelectronics and telecommunications equipment and components, and should define the desired pattern of growth for the production of hardware, software and systems capability. The development of local software constitutes both an essential prerequisite and a major opportunity for several developing countries, and there is considerable scope, particularly for the development of applications software. The development of electronics hardware, apart from consumer electronics, also presents a significant potential for several developing countries and it should be possible to undertake local production of desk-top computers, disc drives, flexible magnetic discs, component boards, keyboard assembly, display assembly, scanners, printers, plotters and memory storage devices. Besides, a wide range of discrete components can be produced locally.

Significant growth can, and should be, achieved in electronics and informatics in developing countries. This will, however, require a major commitment, initiative and support on the part of national authorities.⁹ Apart from the development of basic infrastructure, including training programmes, facilities such as industrial estates and parks for electronics should be considered, preferably in proximity of technical universities and research institutions. An appropriate institutional structure should be set up exclusively for this purpose. A local market should also be developed, uniting the efforts and requirements of defence, telecommunications, information sciences and the industrial sector as a whole.

Development of New Materials

With rapid developments in space, aeronautics and defence technologies in the industrialized countries, there is a growing demand for new materials and for major innovations in materials science. These developments, which are mostly taking place in the United States, Japan and certain European countries, will have considerable impact on developing countries not only with respect to the substitution of materials but because of the changed competitive conditions resulting from the use of such materials.¹⁰ Developments in new materials extend to new

⁹ A. Wad: Microelectronics: Implications and strategies for the Third World, in: Third World Quarterly, October 1982.

cements, high performance ceramics, power metallurgy products, polymers and reinforced plastics and various composites of fibres and polymers and, in the near future, to super-conductive materials. These developments will bring about major changes in the transportation industry and the aerospace sector, besides increased use of optical fibres in the telecommunications sector, a lower metal content in machine-building industries and a variety of other effects.

With the large research outlays involved in high-technology materials research, it may not be practicable to undertake extensive research in most developing countries in fields such as superconductivity, advanced ceramics, polymers and the like. At the same time, there must be increased knowledge, awareness and application capability regarding developments, particularly in so far as they affect the economies of these countries, so that programmes can be undertaken for alternative production or exports, to the extent feasible. It is also necessary that increased attention be given to materials science in research institutions, as well as at university level, in developing countries. Special emphasis must be given to the development of improved construction and other materials which have a direct impact in these countries. Improved materials for low and middle-income housing in rural and urban areas, as well as for road and building construction would be of particular importance. It is also necessary to ensure a greater degree of materials testing and quality control, as well as standardization and metrology.

Biotechnology

A critical field in new technologies which could have a substantial, positive impact on developing countries in the next few years is biotechnology, which involves the manipulation of micro-organisms to produce a variety of products, including foods, chemicals, medicines and industrial enzymes. Biotech applications have developed extensively in several fields, particularly in genetics, with innovative developments in DNA structure and recombinant DNA. The developments have opened up enormous possibilities for the large-scale manufacturing of genetically engineered products and materials. Biotechnological applications extend over a very wide range, particularly in agriculture and agricultural operations, pharmaceuticals and health care, and industry and mining, as well as various other fields.

Developments in biotechnology will inevitably have a considerable impact in developing countries, particularly in agriculture but also in medicine and other fields. In agriculture, major improvements in plants and crops can

be achieved through genetic engineering, including the implantation of nitrogen-fixation genes. Tissue culture and related techniques can bring about considerable improvements in plant breeding and production capability. New and modified species of plants can be developed which could survive in desert regions. Livestock breeding could be significantly improved through genetic applications. The production of proteins, the conversion of biomass to food products and major increases in food production could be achieved through biotech applications. New biotechnology applications in developing countries would largely depend on the extent to which local research resources and capability can be mobilized and directed for this purpose, except for developments in the public domain and where certain innovative developments achieved in other countries can be acquired from private-sector patent-holders on commercial technology transfer conditions. The latter stage may still take some time, as developments in this field are still fairly recent.

The major policy issue on biotechnology in developing countries is the role to be ascribed to local research, and to linkages and the networking of research institutions with bodies engaged in the same field in other countries, both industrialized and developing.¹¹ There is scope and potential for each country to undertake biotech research and tissue culture in relation to its own production priorities and to link local research and production capability with those achieved in other countries. For this purpose, it is necessary to create and sustain an environment that fosters indigenous creativity and innovation in this vital and growing field. Production and applications capability in biotechnology has immense potential in developing countries but has to be structured largely within the framework of local applied research till commercial technology transfer in this field becomes more common.

New technologies present a major challenge, as well as considerable potential and opportunities, to developing countries. Increased absorption and adaptation of such technologies is essential to reduce the growing technological gap between industrialized and developing countries. This can, however, only take place if a concerted and combined effort is made by policy-makers, technologists and entrepreneurial groups in these countries to meet this growing challenge.

¹⁰ L. C. Kaounides: Technology Trends Series No. 13.: The Revolution in Materials Science and Engineering: Strategic Implications for Developing Countries, United Nations Industrial Development Organisation, Vienna 1991.

¹¹ J. de Souza Silva: Biotechnology in Brazil and Prospects for South-South Co-operations, in: Biotechnology Revolution in the Third World, New Delhi 1988.