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Expert Group Meeting on Prospects for Industrialization Policies in Developing Countries Taking into Account the Impact of Developments in the Field of New and High Technologies

Vienna, Austria, 4-7 April 1989

REPORT*

Prepared by the
Regional and Country Studies Branch
Industrial Policy and Perspectives Division

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I. BACKGROUND AND OBJECTIVES OF THE MEETING

The Expert Group Meeting on Prospects for Industrialization Policies in Developing Countries Taking into Account the Impact of Developments in the Field of New and High Technologies was organized by UNIDO pursuant to a recommendation made at the Sixth Meeting of the Intergovernmental Follow-up and Co-ordination Commission on Economic Co-operation Among Developing Countries held in Havana, Cuba, 7-12 September 1987. That recommendation had subsequently been endorsed by the Ministers of Foreign Affairs of the Group of 77 at their meeting in New York, 28 September - 1 October 1987.

The Expert Group Meeting took place in the Vienna International Centre from 4 to 7 April 1989. It was attended by 35 participants from 23 developing countries, 3 representatives from regional and international organizations and 13 observers together with UNIDO staff and 4 UNIDO consultants.[1/]

UNIDO, in co-operation with specialized institutions from a large number of countries, has carried out an extensive study and research programme on emerging trends in the development of new industrial technologies as well as on industrial strategy and policy options for developing countries at the national, sub-regional and regional level. While many of the issues dealt with in these studies have been of a country-specific and/or sector-specific nature, the developing countries are, at the same time, facing common challenges, constraints and prospects for their continued industrialization process going beyond national and sectoral boundaries. The Expert Group Meeting addressed these questions by looking specifically into the interaction between new technological developments, likely changes in the patterns of industrialization and possible industrial strategy and policy responses by developing countries.

The Expert Group Meeting had as its major objectives:

- first, to analyze and assess changing and emerging international patterns of industrialization stemming from new technological developments;

- second, to outline specific industrial strategy options and policy measures for developing countries in response to these developments; and

- third, to strengthen co-operation among developing countries in terms of monitoring international technological developments and designing joint approaches in industrial policies.

1/ The complete list of participants is to be found in Annex I of this report.

The meeting elected three Chairmen: Mr. Abdel el Wehab Bisnry of the Industrial Research Council, Egypt; Mr. H.C. Gandhi of the Department for Technical Development, Ministry of Industries, India and Mr. Luis Maldonado Lince of the Ministerio de Industrias, Comercio, Integracion y Pesca, Ecuador. As rapporteur, Mr. Magdy S. Rady, Second Secretary of the Permanent Mission of the Arab Republic of Egypt to UNIDO, was elected.

The experts from developing countries presented their papers in which the current industrialization and technology trends were outlined and major policies as well as constraints to development were examined.

The representatives from regional and international organizations reported on their current activities and international trends and driving forces relating to new and high technology.

The UNIDO consultants presented particular case studies on new technologies and their implications for developing countries. These case studies are part of the Meeting's documentation and will be published separately by UNIDO. The case studies covered: telecommunications, machine tool industries, textile and clothing industries, biotechnologies and new and advanced materials. In two consecutive working groups the findings and observations presented by experts from developing countries and the international experts were discussed in detail and various conclusions were reached on the major challenges and opportunities arising for developing countries out of the technology fields presented.

In its final session the Expert Group Meeting adopted a summary report containing the main conclusions reached and recommendations made. These are reproduced in chapter III of this final report.

II. SYPNOSIS OF PRESENTATIONS

1. Opening addresses

The Expert Group Meeting was opened by the Deputy Director-General of the Department for Industrial Promotion, Consultations and Technology of UNIDO on behalf of the Director-General. In his opening address, he stated that the Expert Group Meeting was dealing with a most pressing set of problems facing developing countries in the years to come.

Since the end of the seventies the world had been undergoing considerable technological change with the diffusion of advanced technologies based on recent scientific findings. This powerful wave of innovations was having an increasing impact on the different spheres of human activity. The central elements were certain new technologies, principally micro-electronics, informatics, biotechnology and the vast array of new materials.

The developing countries should not resign themselves to a passive role, awaiting in the wings the outcome of this new industrial revolution. They should attempt to moderate negative effects and take advantage of the benefits that may result from incorporating the new technologies into different aspects of their national lives. This would be no simple task given the present unfavourable world economic situation, characterized by low growth in the global economy, increasing protectionism in industrial countries, large external debts and an erosion in the terms of trade. But failure not to make an efforts to face up to this challenge would be tantamount to the developing countries becoming mere spectators in the technological revolution, incurring the real risk of their being marginalized from the world economic and social progress.

The Deputy Director-General went on to put forward some proposals to strengthen and supplement the scientific and technological co-operation between developing and developed countries in both the commercial and non-commercial sphere. These included the following:

- graduate students from Third World countries should be induced to select areas of study and dissertation subjects that are truly relevant to their countries of origin;

- distinguished scientists and teachers from developed countries should be brought to developing countries for longer periods so as to contribute to the training of the current generation of students;

- the negative effects of the outflow from developing countries of high-level human resources (brain drain) should be moderated, inter alia, by improving the working conditions in the respective home countries;

- enterprises from industrial countries should be encouraged to allow more participation of developing country enterprises in complex technology projects for third countries;

- new technology-based enterprises in developing and developed countries could co-operate in designing 'nurseries' and science parks and in helping in the creation and development of venture capital firms.

In these and other efforts pertaining to a better diffusion of new technologies regional co-operation among developing countries was of great importance in pooling and complementing national efforts. Furthermore, an analysis should be made of the possibility of establishing technical co-operation between the large European pluri-national programmes and corresponding programmes emerging in different regions of the Third World.

In her opening address, H.E. Mrs. M. Tallawy, Ambassador and Permanent Representative of the Arab Republic of Egypt to UNIDO, Chairperson of the Group of 77 in Vienna, emphasized that the new technologies under consideration would challenge traditional economic theories of industrial development and reflect upon the future of both North-South and South-South relations and co-operation. The current technological challenges were emerging at the end of a 'lost decade' of development coupled with depressed commodity prices, uncertainties in the monetary system, increasing external debts and structural adjustment burdens. Due to the increasing replacement of low cost labour by high-tech automation equipment and the graduai substitution of primary commodities by advanced materials the developing countries were deprived of their established comparative advantages.

An integrated and consistent industrialization strategy with clear objectives and priorities was called for taking into account a multitude of interrelated areas, such as the interplay between the private and the public sector, industry-oriented R&D activities, human resource development needs and technological trends. Special attention should be paid to investment in human capital, particularly training and re-training of skilled labour. Another area deserving careful analysis was the specific types of technologies to be applied in developing countries and in this context the question of whether they should be imported or generated domestically.

H.E. Mrs. Tallawy, further pointed to the critical importance of avoiding a 'two cultures syndrome' in developing countries, i.e. a situation in which the process of technological advancements on the one hand and the socio-economic development process on the other were pursued largely independent of each other. More than hitherto, developing countries should also strengthen their joint efforts in generating and applying new technologies and in seizing the related industrial opportunities.

The Head of the Regional and Country Studies Branch in his preview of some of the meeting's main issues drew attention to the changing international context of development. In the 'golden age' of growth in the 1960s and early 1970s the developing countries had been able to significantly increase their industrial capacities and technological capabilities in the process of global industrial restructuring. The 1980s, however, were characterized by increasing financial and foreign exchange constraints, uncertainties in internationa' trade, dramatic technology developments and associated organizational innovations - together resulting in drastic changes in the pace and patterns of developing countries' industrial development. It was at this critical point of time that the nature and impact of new technologies needed to be reassessed by the policy-makers in developing countries. This assessment should go (a) beyond engineering and technical aspects to also include economic implications, (b) beyond global analyses to also include specific conditions at the country level and (c) beyond empirical research to also include forward-looking aspects.

Some of the major issues to be discussed included trends signalling the erosion of established patterns of trade and comparative advantage; flexibility requirements in view of shorter product cycles and rapid changes in production processes; increasing R&D intensity of industrial production; the crucial role of comprehensive data and information systems for efficient production and marketing; new educational approaches towards skill upgrading; and the modes of closer interaction between research, finance, production, administration and policy-making in developing countries.

2. Presentations by country experts[1/]

The Expert Group Meeting devoted considerable attention to the presentation and discussion of the experience of developing countries in applying new and high technologies in industry and to their perceptions of the major issues to be dealt with by forward-looking industrial strategies, policies and measures.

The expert from Algeria pointed out that - partly due to the dominant role of petrochemicals and other basic industries in the country's economy - the introduction of advanced technology had so far been confined to public sector industries. He stressed that in the past emphasis had been put on turnkey projects with a view to save time in catching up with the 'industrial caravan' of the twentieth century. Currently, however, several international engineering projects were being placed back into domestic hands and it was essential to achieve a balance between external and domestic inputs in the future. Among the main requirements for a more effective utilization of new technologies were an emphasis on applied research and better linkages between research laboratories and industry; a constant re-training of industrial staff; and intra-industrial redeployment of skilled staff. The expert further stressed the crucial role of small and medium enterprises in adapting advanced technologies to local conditions. Technology centers were essential to advise industrial enterprises on all aspects of introducing new technologies.

The expert from Burkina Faso characterized the country's industrial sector as being largely based on import substitution with a heavy emphasis on food industries. Policy emphasis was more on employment creation than on introducing high technologies - in an overall context of a high level of unemployment, a small domestic market and a predominance of small and medium enterprises. In addition to market size, the high acquisition cost of new technologies coupled with the high level of foreign indebtedness was seriously constraining the introduction of new technologies. Likewise, the country's two national research institutes were facing financial difficulties in carrying out their research programmes. The key role of better technology information services was emphasized with a view to support the technological upgrading of small and medium enterprises.

The expert from Cameroon outlined the country's economic policy approach since independence which had shifted from integrated liberalism to

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1/ This section provides a sypnosis of the country presentations made at the meeting covering first African countries followed by Asian countries and Latin American countries. A list of country papers distributed during the meeting is given in Annex 2. Copies of the country papers in their original language are available from UNIDO upon request.

community-oriented liberalism. Due to the dominance of raw materials based processing activities the industrial sector had been hit hard by falling commodity prices. In this overall situation of industrial decline, a lack of coherent industrial structures, shortages of skilled labour and a weak R&D infrastructure the initial response to emerging new technologies had been defensive. The expert emphasized that - however difficult it may be - the country had no chance now but to react to the existence of powerful new technologies which were being introduced in the advanced countries. He stressed that a broad range of factors was hampering the adoption of new technologies. These included such obvious aspects as high acquisition costs yet also broader social and cultural issues of being exposed to hitherto unknown technologies.

Egypt's expert elaborated upon the country's Second Research & Development Plan 1987-92 in which, inter alia, priority was assigned to the establishment of national centers for new and advanced technology, the networking of technological development in various key fields and generally the creation and promotion of innovation talents. Increased technological self-reliance was a main objective in meeting the challenge of either progressing or being left behind. In terms of priority technology areas the Plan singled out microelectronics, biotechnology, new and renewable sources of energy, materials technology, laser technology and applications, information technology, health services and ocean & sea exploitation technology. Studies were underway and to be finished in June 1989 taking stock of the country's situation in these fields. With qualified human resources available in abundance, the shortage of finance and particularly hard currency to generate and/or acquire new technologies was identified as the crucial bottleneck.

The expert from Ethiopia drew attention to a wide range of constraints which any endeavour to promote industry-oriented research and development was facing in the country. Apart from an insufficient appreciation of the importance of R&D in most industrial enterprises these included inadequate financing of R&D projects, shortage of scientific manpower and brain drain, lack of initiative for innovation, poor science and technology infrastructure and the absence of an explicit science and technology policy. It was essential, however, to make investment decisions in the light of perceived trends in industrial technologies and changing patterns of competitiveness. Action immediately called for included the introduction of competitive mechanisms in public sector enterprises, the enhancement of university-industry linkages, the review of curricula at all levels of education and, most of all, efforts by international organizations to promote the early diffusion of information on new technologies among developing countries.

The expert from Ghana expressed concern that the generation and application of new technologies in the developed countries may cause a disruption in the further development of Third World countries. The substitution of biotechnologically engineered products and new materials for natural materials already posed a great threat to many commodity exporting countries. Nevertheless, to fight for protection of their economic structures was no real option. Rather it was essential to keep abreast of the new technological challenges. In Ghana, the present utilization of new technologies was very low; examples given included micro-computers in private sector saw mills for precise slicing of timber as well as in the aluminium processing industry for the control of boilers. A National Technology Plan

was being prepared by the Council for Scientific and Industrial Research. Regional and international co-operation agreements in the field of science and technology were making important contributions as was the case e.g. with the Third World Academy of Science.

The expert from Niger described the country's institutes and centers carrying out research and technology development for industry and agriculture. Priority areas of research included the development of new agricultural varieties adapted to the given environmental conditions; prototype development to promote the commercial utilization of solar energy; and the development of pharmaceutical products, particularly those based on traditional medicines. All these efforts were seriously constrained by the unfavourable geographic position of the country (land-locked and drought-stricken), the smallness of the domestic market, insufficient human and financial resources and lacking mechanisms to diffuse results achieved in research institutions. As to imported technologies, it was essential to adapt them to the social and cultural context prevailing in the country.

The expert from Sudan referred to the country's richness in natural resources which - due to a widespread lack of capital, experience and technology - had remained, however, largely unexploited. Textiles was a case in point: Sudan, though a major cotton producing country, was in urgent need of expertise to manufacture textiles products competitively. The same applied to the field of traditional herbes from which medicines could be produced if the required technology was available. Important impulses for innovation were to be expected from the new sugar training center established by UNIDO. This center had the twofold objective to introudce new sugar-processing technologies and to provide the required training for workers. It could also be used as a means for co-operation with other African countries in this field.

India's expert reviewed the country's past efforts and significant achievements in high technology areas such as space technology, atomic energy and electronics. Furthermore, the country had achieved self-sufficiency in foodgrain production through inputs of modern science and technology. A major policy objective now was to develop internationally competitive technologies with export potential. India's high technological competence had resulted in considerable expertise and capabilities to execute projects in other developing countries, inter alia, in power generation and distribution, water treatment, environmental pollution control, construction and in the provision of related consultancy services. The engineering industry had been the 'mother industry' in the country's industrial development process, with important spillover effects on other branches of industry. A close network of national R&D laboratories and firm-level R&D set-ups was existing. In order to bridge some remaining gaps e.g. in product design and systems engineering technologies, an incentive scheme for technological upgradation had been introduced. Highly focussed technology education programmes as well as the pursuance of mission-oriented technology programmes in critical areas were the main tasks ahead.

The expert from Iraq discussed the role of new technologies in the context of the country's recent priorities to develop minerals-based downstream industries, and steel and aluminium production. In these areas, high technology was employed to alleviate shortages of labour which represented a major limiting factor for industrial development. Furthermore, the utilization of modern equipment contributed to meeting high product

quality standards and exacting specifications required to compete in international markets. A major shift had taken place recently regarding the mode of technology acquisition. Close co-operation between international companies and Iraqi counterparts was now increasingly being substituted for the previsous emphasis on turnkey projects. As to efforts in the field of R&D, a number of specialized institutions were in place yet co-operation between these research bodies and industry was not up to the required level.

The expert from Jordan described the country's industrial sector as being dominated by small- and medium-scale establishments concentrating on the production of a narrow range of consumer products. With mining industries accounting for about 70 per cent of total investment and 60 per cent of industrial exports, there were serious imbalances and very few interlinkages in the industrial structure. In 1987 the Higher Council for Science and Technology had been created in an attempt to integrate and plan the country's R&D efforts previously carried out more on an ad-hoc basis. The application of new technologies was difficult in a situation of a small market and a lack of industrial linkages. However, it was becoming a necessity in some fields of industry. Co-operation with other developing countries (e.g. in the framework of the Arab Council for Economic Co-operation) was required in view of the high prices of technology acquisition from developed countries.

The expert from Kuwait explained that the role assigned to the industrial sector in the country was to contribute to a diversification away from oil as the only base of the economy and to provide productive employment opportunities. Progress had been achieved in the last two decades in starting downstream activities such as oil-refining and the manufacture of petrochemicals. It was crucial in this context to provide more and better training to Kuwaitis as the requirement for skilled labour in manufacturing had so far been largely met by expatriates. As to further constraints in the country's industrialization process reference was made to the small domestic market, lack of natural resources apart from crude oil and natural gas, and the high cost of imported machinery and equipment. The Gulf Co-operation Council (established in 1981) could be able to overcome some of these constraints at a sub-regional level.

The expert from Malta emphasized that the country was at present laying the economic foundations to prepare itself for the unified European market in 1992 and its eventual membership in the European Economic Community (EEC). In this process, clear priorities regarding the most promising fields of new technologies were essential to ensure an optimal allocation of scarce financial and research resources. A National Council for Science and Technology had been set up, existing research centers were being strengthened and Government laboratories reorganized so as to improve services in fields such as measurement, calibration and testing. The country was at present being promoted as manufacturing base for small and medium electronic companies seeking access to EEC and Mediterranean markets. It was the general policy of the Government to diversify the industrial base to include industries concerned with information technology and biotechnology. Plans were being drawn up towards the setting up of a science park on the grounds of the University of Malta.

The expert from Saudi Arabia pointed out that new technologies were very important to the country's petrochemical industries processing hydro-carbon resources. There were two methanol plants and three fertilizer plants with

world-scale capacities exporting products to about 65 different countries. Latest technology was being used in these plants particularly in the area of control equipment and related software. Valuable experience had been gained in selecting the suitable technology for these plants which had either been imported from industrialized countries or brought in by joint venture partners in the companies concerned. Skilled manpower, above all for R&D activities, were the main constraints the removal of which would require increased training efforts. In this context, international co-operation, including co-operation at the company level, was an essential element.

The expert from Thailand informed that recently an Industrial Technology Information Unit had been set up in the Ministry of Industry to collect, process and disseminate data on technology transfer as well as to serve as national focal point for the ASEAN Science and Technology Information Exchange System. The key priority areas of new technologies were biotechnology-based industries and electronic industries. The country continued to be import-dependent in key technology areas partly due to lacking domestic components manufacturing. Furthermore, the existing joint ventures did not pursue active technology acquisition strategies. More innovativeness could be stimulated by a highly competitive atmosphere and the avoidance of overly high protection rates. Specific policy measures taken included tax incentives for small and medium enterprises to acquire new technologies and the envisaged establishment of science-based industrial parks. Moreover, there was a need to improve the utilization of existing R&D centers by industry, possibly through the establishment of a special venture capital fund aimed at encouraging R&D efforts of small and medium enterprises.

The expert from Viet Nam reviewed recent industrial development trends in the country and the emphasis given to the education and training system. Progress had been achieved by national R&D programmes, particularly in microelectronics and biotechnology although it was difficult to take on the challenge of new technologies in an overall context of underdevelopment. There was an urgent need for an improved communication network which could be efficiently linked up with regional and international networks. At present, there was a bias working in favour of basic research. Insufficient management capabilities as well as gaps between R&D efforts and the limited absorptive capacity of industrial enterprises were seen as further serious constraints rendering existing R&D centers often ineffective. A long-term industry-oriented science and technology policy and increased international co-operation were needed to redress the existing imbalances.

From the UNIDO Secretariat some observations were made on the experience of Argentina in building up its national Atomic Energy Agency. It was stressed that in venturing into new high technology fields an organic approach was required, i.e. starting from a small base of core activities to which others can be continuously added. The Argentinian atomic energy programme had begun with the development of the main research disciplines involved and an exploration of the related resources available. At a later stage, a first pilot reactor had been set up and radio-isotop s developed before the establishment of the first nuclear power plant had been launched. This had been accompanied by a package of feasibility studies, negotiations with international suppliers and the identification of domestic capabilities with a view to build up a nuclear technology industry in the country. At the same

time, a large-scale training programme abroad had been carried out. At present, the country had proven its capability to fully design new research reactors and export operations to Peru, Algeria and other countries were underway. In general, to make a real step forward in high technology areas, it was crucial to design a long-term stable programme, to ensure an adequate allocation of Government resources and the commitment of highly motivated experts to the programme.

The expert from Brazil explained the country's new economic strategy called 'competitive integration' which was aimed at achieving international price and quality standards of manufactures and was going beyond the false dichotomy of import substitution versus export promotion. New technologies played a key role in this new approach with informatics, telecommunication, biotechnology and new materials being the priority areas. The crucial decision faced by Brazil (and other developing countries) was the development of criteria as to which products in these fields should be produced domestically and which should be used but be provided externally. A sequence was often to be observed in terms of starting as a user and then becoming also a supplier of high technology products. In some field of informatics, such as micro-processors, Brazil had acquired sufficient critical mass to be an internationally competitive producer. In general, it needed to be pointed out that technological upgradation strategies required strong national efforts. At the international level, there was a danger, however, of high interest rates, protectionism and commercial retaliation aborting any such efforts by developing countries.

The expert from Cuba gave a historical review of the country's industrial and technological development starting from the pre-independence period. After having reached independence the Government had developed a coherent technology policy in line with the country's needs and priorities and based on its social and economic conditions. To ascertain such coherence had been and continued to be the role of the state. As regards technology transfer and the provision of external inputs a suitable framework had been established through a comprehensive technical co-operation agreement concluded in 1972 with the USSR. Generally, it was important to monitor all imports of technology to ascertain that they are really required, adapted to the country's needs and delivered on acceptable terms. Co-operation between developing countries was essential in this context. Research in genetic engineering and biotechnology was among the priority areas of new technologies in Cuba. Particular emphasis was placed on applied research in the fields of medicines and nutrition. The positive results of this approach included a low level of infant mortality, high life expectancy, a successful struggle against contagious diseases and a high self-sufficiency ratio in the provision of medicines to the population.

Ecuador's expert stressed that technological innovation had a vital yet only partial impact on industrial development and that many developing countries were faced with the challenge of new technologies at a time when they were undergoing deep economic crises. In Ecuador, the large informal sector as well as many social constraints on educational efforts were acting as detrimental factors to the introduction of new technologies in industrial production. The priority sectors were food, textiles/clothing and construction. It was essential to first consolidate existing capabilities in those sectors before new technologies could be introduced within an overall industrial restructuring strategy. UNIDO should act as a driving force to enhance technology transfer in this process. Furthermore, it was of utmost

importance that a close alliance be sought between the state, industrialists and trade unions in implementing a mutually agreed industrial policy.

The expert from Jamaica pointed out that the country - being located in front of the world's largest market - was directly exposed to all major new technologies, particularly in the field of telecommunications. This posed a formidable dilemma: hesitating to enter into new technologies was to commit economic suicide whereas active participation required resources hardly available in the country. The Government had identified several industrial sub-sectors with actual or potential comparative advantages in the world market and policies had been introduced to assist them in harnessing new technologies. Technology transfer from abroad was an essential input in this process yet only in cases where competent local counterparts were available. Biotechnology was at present receiving concentrated attention from the local university whose research centre was also carrying out contract research for industry. Progress in the information-processing industry had been impressive with participation of both small companies and foreign investors. In this context, the establishment of a teleport facility (offering services in the areas of data entry, information-processing, data-base linkages, telemarketing etc.) had been a crucial step forward to further increase the attractiveness of Jamaica as investment location.

The expert from Mexico[1/] described the situation which the country was facing as it confronts new technologies such as microelectronics, informatics, telecommunications, biotechnology and new materials. Although in the past Mexico's industrial sector had experienced rapid growth, it was characterized by lack of efficiency and competitiveness. The crisis of the early eighties called for a radical reorientation of industrial strategies and policies; raising productivity and international competitiveness had become major objectives with a view to modernize established industries and to resume the vigorous industrial growth rates of the past. Thanks to special promotional policies, notable results had already been achieved in the electronics industry; especially investment in and production of computers had increased significantly. Although there had been advances in research and development efforts in other areas of new technologies their development was seriously hampered by a lack of funding and a severe shortage in human resources which appeared to be the most critical obstacle in the development of new technologies. There was reason to be confident, however, that the new economic policies which placed emphasis on free trade, deregulation, promotion of foreign direct investment, private initiative, an enhanced integration of research institutes and the private sector, as well as the existence of public institutions experienced in the promotion of technological progress, would show important advances in the near future.

1/ The Mexican paper was distributed at the Meeting as the expert was unable to attend due to unforeseen reasons.

3. Presentations by experts from regional and international organizations

The expert from the Economic and Social Commission for Western Asia (ESCWA) reviewed recent achievements, strategies and issues with regard to key new technologies in the ESCWA region. In microelectronics, there was a significant and increasing market for both consumer electronics and industrial electronics, in the latter case particularly for micro-processor based control equipment in the oil industry. Many countries were producing electronic items on an assembly basis with product designs and major components being imported. R&D was undertaken in many national centers and universities though largely unrelated to industrial needs. National strategies for the advancement of microelectronics technology and its applications had been formulated in some countries, notably in Egypt and Iraq. Likewise, in the field of telecommunications assembly operations were being carried out in some countries to produce telephone exchanges, cables and telephone sets. Scope to produce further equipment items had been identified in a recent study undertaken by ESCWA which had been further substantiated by a feasibility study for the Arab Industrial Investment Company (AIIC). One recommendation was to produce digital exchanges in Egypt and Algeria on a sub-regional basis. Regarding biotechnologies, research was undertaken in many national research centers with the main thrust being in the field of agriculture with a view to improve the quality and quantity of production. The general conclusions drawn for the ESCWA region by the expert included the following. Although the region as a whole had adequate financial resources and a large pool of trainable university and technical school graduates, the present state in the industrial utilization of advanced technologies was weak. There was a critical lack of coordination between universities, research centers and industry at the national and regional level. The promotion of regional approaches in meeting the challenge of new technologies was essential, in particular to prevent the widening of technology gaps between the countries of the region.

The expert from the International Labour Organization (ILO) summarized the most recent activities of the organization's international division of labour programme. Within this programme studies were being undertaken on structural changes in manufacturing industries in both developing and industrialized countries. The introduction of new technologies played an important role as determinant of structural change yet it was to be put into a broader framework encompassing further aspects such as changing patterns of demand, investment, trade and finance. The ongoing research at ILO was focussing on the political economy of industrial restructuring in the developed and some more advanced developing countries. To this end, four industrial sectors had been singled out for in-depth global studies. These sectors included clothing and automobiles (studies already completed) as well as steel and aircraft (studies under preparation). The global studies were being supplemented by case studies considering the actual development of production, trade and employment of these industries in selected countries. Emphasis was put on analysing at the national level the role of institutions and the strategies of governments and of enterprises including their interaction to produce desired - or sometimes undesired - results. The case studies already completed included: United Kingdom, Republic of Korea and Mexico on the automobile industry; Italy on the clothing industry; USA and India on the steel industry; and Singapore, Indonesia and Brazil on the aircraft industry.

The expert from the United Nations Conference on Trade and Development (UNCTAD) reviewed the impact of recent technological advances on international trade. He pointed out that due to the substitution of raw materials, reduced wastage, higher knowledge intensity and decreasing raw materials intensity of manufactured products there was a trend for the share of raw materials in international trade to decline. Likewise, the patterns of trade in manufactures were increasingly influenced by technological change. Recently, there had been significant shifts in the relative competitive position of countries and groups of countries caused, inter alia, by the degree of innovativeness in rationalizing production methods and raising product quality. The capturing of market shares was determined more by the level of acquired technological competence than by given resource endowments. Shorter product cycles and high rates of innovation were an important way of maintaining higher levels of wages and profits in the leading countries. At the same time, some governments in industrialized countries had adopted several types of measures to stimulate and/or protect their high technology industries. These measures included the increasing neglect of the unconditional most favoured nation clause, the introduction of conditional trade regulations and the provision of grants and soft loans to the industries concerned. While the multilateral trading system at present was more and more eroded, the strengthening of an open trading system was essential for developing countries to improve their position. Furthermore, a solution to the debt problem was a necessary condition to free resources for industrial and technological development efforts.

4. Presentations of technology case studies by UNIDO consultants[1/]

Five detailed technology case studies were presented at the Meeting by international consultants and discussed extensively in different working groups. They included telecommunications, microelectronics (as applied in the machine tool industry and the clothing industry), biotechnology and new and advanced materials. These presentations are briefly summarized below.

a. Telecommunications

The expert on telecommunications first reviewed the wide-ranging technological developments which had recently taken place in this area and which had affected exchange technology, transmission equipment and peripherals alike:

- digital exchanges were being introduced which are solid-state (without moving parts) implying fewer breakdowns and less maintenance requirements than conventional electromechanical switching systems;
- transmission equipment was revolutionized by fibre optics and laser transmission systems which are superior to conventional systems in terms of greater capacity, speed, flexibility and resistance to interference;
- peripheral equipment now comprised a broad range of 'intelligent' terminals and telephones, key systems, mobile radios and a variety of new office equipment.

1/ The five Technology Case Studies and the Issue Paper prepared by UNIDO (see Annex 2) will be issued in full length in a separate publication.

With these wide-ranging innovations, telecommunications even more than before was becoming a critical element of any country's industrial infrastructure. Consequently, any development strategy which in anyway was dependent on international linkages for finance, technology, goods and services and/or involved the local participation of foreign firms in any sector of the economy would face considerable and growing difficulties in the future if an adequate, digital-based telecommunications system was not in place.

Within the developed countries, the basic telecommunications infrastructure had long been in place, telecommunications services were used as an integral part of the productive effort in the economy and there was a wide range of domestic enterprises able and willing to supply both services and equipment under competitive conditions.

Many developing countries, however, lacked the basic telecommunications infrastructure and a viable domestic equipment and service supply sector that exist in the industrialized countries. Consequently, and in contrast to developed countries, the predominant policy concern and objectives of developing countries in relation to telecommunications were to build up the basic telecommunications network and to respond to the needs of a growing economy.

Such endeavours were now meeting with favourable market conditions. A break-up of old oligopolistic market structures by new suppliers had led to fierce competition turning the production of telecommunications equipment into a buyer's market. In these circumstances, it was essential to reform and strengthen national PTTs (Postal, Telegraph and Telephone Agencies) with a view to increase their organizational efficiency and technological competence and to enhance their bargaining power vis-à-vis foreign suppliers. Emphasis should be put on the involvement of foreign suppliers in gradually building up local supply capabilities of telecommunication equipment with the manufacturing of peripherals being a starting point. Training, retraining and technical assistance was essential to support national learning efforts which - due to the modular and horizontal nature of telecommunication technology - could be of great importance also for other sectors of industrial information technology. Complementary to building up supply capabilities it was seen essential to make local user industries aware of latest technological trends and increase their absorptive capacity in efficiently applying telecommunication equipment and services.

This would require considerable efforts in training and retraining of engineers in order to generate the skills needed for efficient operation and maintenance of latest telecommunications technology.

b. Machine tool industry

The expert on technological advances in the machine tool industry stressed the drastic structural changes which were taking place at present in this branch. Numerically-controlled (NC) machine tools had captured major market shares in recent years. In the leading industrial countries the share of NC machine tools in total production of machine tools had risen from approximately one quarter to approximately two thirds within just a decade (1976-86). This was a powerful indication of a most important technological development in modern engineering industries, namely the fusion between mechanical and electronic technology, now often referred to as

'mechatronics'. This emerging mechatronics revolution was not only affecting machine tools but also industrial robots, measuring technology etc. and thus was increasing the technical and economic feasibility to integrate machine tools with other industrial machinery both on the shop floor and in the office.

There existed, however, a considerable diffusion gap between the developed countries and even those more advanced developing countries which have become significant users of NC machine tools. The leading developing countries in terms of user density (number of NC machine tools per employee in the engineering industry) had now achieved levels in the order of 50 per cent of those prevailing e.g. in the UK, the FRG and the USA. Looking at the machine tool investment rather than stock figures the gap was even more accentuated: the share of NC machine tools in total machine tool investment ranged between 40-60 per cent in most developed countries yet only between 10-25 per cent in the more advanced developing countries. With most developing countries falling far behind, the technology gap in this area was in fact widening rather than narrowing. Accordingly, the industrialized countries were benefitting more from this new technology than the developing countries with resulting negative effects on the international competitiveness of metalworking industries in the developing countries.

Key obstacles to a more rapid diffusion of NC machine tools in developing countries were lack of information, lack of skills and knowledge, high relative prices of NC machine tools and inadequate access to the full range of different NC machine tools. Removing these obstacles should be a major goal of government policy with a view to reduce the gap between actual and potential diffusion of NC machinery in industry. Main elements in this should be (a) diffusion of information about the technology e.g. through national institutes, (b) evaluation of developed countries' experience with subsidizing industrial showcases and (c) orienting the educational and training system towards the new electronic, computer and software skills required.

Special attention was drawn to the situation of developing countries seeking to gradually build up local supply capabilities in the production of NC machine tools. As in the metalworking industry in general, there was a very considerable degree of international trade in machine tools. As long as the development strategy of a country as a whole did not rely greatly on trade restrictions, the amount of machine tools that the local metalworking industry sources locally tended to be small due to the high benefits of specialization that existed in the industry. Hence, the domestic machine tool industry could not, on the whole, be seen as strategic in the sense of being a transmitter of new technology to the local engineering industry. In today's world, it was the global machine tool sector which acts as a global transmitter of new technology to the global metalworking industry.

It was crucial, therefore, that attempts to create an advanced machine tool industry in a developing country were not putting the local user industries at a disadvantage - either in terms of higher prices or a reduced scope for choice of different variants of NC machine tools. Reliance on credit policies and technology policies was generally preferable to the introduction of tariff protection and/or quantitative import restrictions.

c. Clothing industry

The expert on new technologies in the clothing industry pointed out specifically that technological changes were to be seen as an important yet

only partial determinant of competitiveness and structural change. The dramatic predictions of the early 1980s foreshadowing a broad relocation of clothing production to the North due to microelectronics-based shifts in competitiveness had not materialized. In general, the clothing industry had shown a solid 'resistance' to automation pressure in its central production stage, viz. the assembly of cloth which had remained a domain of labour-intensive operations on traditional or programmable sewing machines. Ambitious R&D programmes were underway in some developed countries to achieve full automation yet their breakthrough in terms of commercial applications was not expected to take place in the very near future. While these attempts should be closely and carefully observed the real threat to developing countries' clothing producers continued to be the increasing market protection in most importing countries. Furthermore major changes were to be identified at present in the international clothing production and marketing system which appeared to be at least as important factors as technological change. Among these the following were particularly emphasized: (a) changing consumer preferences leading to higher design content of products and to shorter lead times for producers which are facing almost continuous fashion changes, (b) new types of buyer-supplier relationships with more emphasis on long-term stable relations including technical and design assistance provided to suppliers, (c) wide-ranging changes in production organization including just-in-time systems, group technology, increased responsibility of multi-skilled workers, electronic point of sale systems etc. All these factors were putting a premium now on flexibility and quick response in the production of highly styled, top quality garments. Medium-sized companies had shown to meet these requirements superbly in many developed and developing countries. It was essential, however, that their high innovativeness and creativity be supported by a range of collectively provided services in areas such as design, export marketing, training facilities, technological information and consultancy services.

The new best practice approach to production organization and the training of workers beginning to surface in the developed countries' clothing industry was then reviewed in more detail. Production lines were being reorganized along flow rather than batch principles; inventories and lot sizes were being reduced while varieties were increased; workers required new and broader skills to respond to the new demands of varied output and more flexible work organization; and incentive systems were to be recast to take account of their higher skills levels and greater responsibility.

Can these new organizational practices be transferred to developing countries? On the one hand, there were many reasons to argue that it will be extremely difficult to introduce the new practices in developing countries. Clearly, there would be major obstacles. All of the financial, economic and market-related problems that currently constrained efforts to raise productivity and improve quality in the Third World would tend to work against the introduction of new practices. The most critical of these were likely to be skill constraints. The new practices were particularly demanding of managerial and engineering skills of which there were severe shortages in developing countries. Another obstacle was the distorting effect of highly protected markets on incentives for firms to undertake any innovative efforts at all. This problem would be particularly pronounced in cases of excessive state intervention in production.

On the other hand, there were a number of factors suggesting the existence of favourable preconditions in developing countries for introducing

the new methods of production organization. These included the fact that (a) many of the new practices were neither scale- nor sector- nor product-specific, (b) the knowledge required to implement these organizational innovations was neither patented nor restricted or highly priced, (c) they did not necessarily require investment in embodied technology thus keeping the costs of introducing the new practices relatively low and (d) in a number of cases - including a large clothing company in Brazil - they were already being successfully operated.

Taken together, these points appeared to constitute a powerful a priori argument that the new practices could be successfully introduced in developing countries not only in the clothing industry but across different industrial sectors. Indeed, it could even be argued that they could be introduced across a far wider range of countries and sectors than was the case for the new computer-based technologies which were suitable only for the more advanced developing countries.

d. Biotechnology

In the presentation on biotechnology attention was drawn to the fact that traditional biotechnology processes applied in many developing countries may serve as a springboard for entering into new advanced processes. A major stimulus had been given to the field of biotechnology in the 1970s with the advent of new powerful techniques, above all the ability to move genes between organisms and the ability to change the structure and functions of proteins. At present, pervasive implications and effects were occuring over a wide range of industries leading, inter alia, to traditional borderlines between sectors becoming increasingly blurred. Generally, it was to be noted that the entry barriers in biotechnology - though significant - were relatively low when compared to crucial areas of information technology, such as superconductors and digital switching equipment. This had been witnessed by the emergence of a large number of small new biotechnology firms in developed countries. There was, however, a long time-lag until the new techniques could be widely commercially applied, i.e. until knowledge was translated into economic value.

Significant interlinkages were at present being created between advances in biotechnology and those in microelectronics. On the one hand, new information processing technologies were having an impact on the efficiency of biotechnological processes. Examples were to be found in the use of microprocessors and computers in automated control of bioreactors and DNA synthesizers. On the other hand, biotechnology was beginning to have an effect on information processing although this effect was not yet as great as the other way round. For instance, one area of application for protein engineering was in the field of biosensors and biochips where integrated circuit technology was fused with protein engineering technology.

Only a few marketable products had so far been created from the 'new' biotechnology, inter alia because lead times for product development, including testing and approval, tended to be very long and often unexpected problems emerged in the process of scaling-up. Examples of commercial biotech-offspring included the anti-cancer agent interferon, human insuline and growth hormones in the field of pharmaceuticals as well as tissue culture, sugar-substituting sweetners and the cloning of oil palm plants in the area of agro-industry.

The latter two developments were already having substantial effects on the international sugar market and on the vegetable oil market. The gradual substitution of non-sugar sweetners for sugar had contributed to a further oversupply and low prices in world sugar markets; high productivity oil palms would lead to shifts in cultivation (e.g. away from rubber into palm oil because of higher yields) and could eventually also result in price decreases for all vegetable oils.

It was of crucial importance for developing countries to recognize that the generation and diffusion of biotechnology required the building up of a biotechnology-creating system. This was not easy to establish as the various key elements were to be found in different actors and organizations (such as firms, research institutions, government bodies, banks). The main elements were referred to as the development of (a) core scientific capabilities in selected priority areas; (b) company-level capabilities for bioprocessing and commercialization; (c) national-level capabilities in terms of an appropriate infrastructure (power supply, transport system etc.); and (d) additional assets such as finance and access to marketing systems. The functioning of such an overall system should be the focus of government policy in terms of encouraging interaction and linkages, creating transfer agencies between the actors involved and establishing a conducive institutional setting (e.g. through science parks).

At the present incipient stage of developing industrial applications of biotechnology there were significant opportunities for economic co-operation among developing countries. These included, inter alia, the development of biotechnology-based products particularly suited to the needs of and conditions prevailing in developing countries; complementary specialization in science disciplines and training efforts; exchange of information on the successful adaptation of existing biotechnologies to specific circumstances and co-operation in the regulation of biotechnological research and development, e.g. through the enforcement of codes of practice among concerned scientists.

e. New and advanced materials

Recent advances in the field of new and advanced materials were seen as a high technology area of great significance expected to develop its full impact on industrial development and competitiveness towards the late 1990s. Increasing attention was now being paid to recent scientific and technological developments which had led to the creation of highly engineered advanced materials. These comprised a number of distinct yet connected clusters of materials such as engineered plastics, advanced ceramics, composites, advanced metallic alloys and superconductors.

The quintessence of progress made in such interlinked fields as physics, mathematical modelling, computer science and advanced instrumentation was that material scientists can now intervene directly at the microstructure of materials. Consequently, it was less and less the availability and properties of specific materials which constrained the development of end products. Rather, one could now in many cases start from the required properties and performance elements of a product and then develop and process tailor-made materials for the particular application. From this, a vastly accelerated rate of materials and product innovation followed as well as rapid obsolescence of existing products and processes, and reduced life cycles for new materials. No single material would dominate the market for long periods, as used to be the case in the past.

Furthermore, it was likely that the materials which will dominate industry in the 21st century, would be 'materials systems'. Composite and laminate materials systems tailored for specific applications and environments would gradually displace monolithic or homogeneous materials, such as metals.

The early incorporation of such materials into new products and processes resulted in higher value added, improved competitive positions and accelerated market penetration. Hence, a successful advanced materials sector would increasingly contribute to maintaining or acquiring international competitive advantage. Many governments had already recognized the potentially harmful effects on output, employment and trade of falling behind in advanced ceramics, polymers and composites.

Moreover, the advent of advanced materials may significantly influence industrial location decisions in the future, particularly when seen in a broader perspective. The introduction of computer-based manufacturing systems, together with just-in-time inventory control and total quality management, implied a tendency towards proximity of materials suppliers to industrial end users. Indeed, advanced materials had in some cases been developed specifically to eliminate import dependence on critical production inputs. It may thus be expected that e.g. the demand for some metals would be negatively affected as advanced materials gained a stronger foothold in the developed countries' industries in the future.

Whether developing countries remained in primary and processing activities or not, their industrial base would need to function, operate, compete and survive in a global market increasingly dominated by microelectronics-based technologies and advanced materials incorporated in both processes and products subject to great scientific content and rapid change. In order to produce and compete in the world market, to induce foreign direct investment in manufacturing and to import and efficiently use new technologies, certain minimum preconditions were required in terms of infrastructure, education, skills, experience, locally available networks of supplies, spare parts, professional expertise, etc., in the new technologies. At some point developing economies had to move in this direction, within the means at their disposal.

If primary producers wanted to remain in primary production and processing they would need to ask for how long and under what conditions this was feasible. If they wanted to stay on a long-term basis then they had to decide whether they wished to remain commodity producers or move further downstream to higher performance, higher value activities. In the latter case, they needed to ask if such production would be oriented towards an emerging South market for such materials and/or niche markets in developed countries. For either markets, they needed to determine what form of collaboration or dependence that entails with foreign companies. And finally, how the strategy in the primary sector was in consonance with an industrial strategy designed to meet the technological challenges of the 1990s. The integration of domestic materials production with a domestic or regional capital goods sector would need to be evaluated in the light of perceived needs to acquire expertise in the production and use of new materials.

III. CONCLUSIONS AND RECOMMENDATIONS[1/]

1. Summary of findings

Change has become an inherent feature of the global environment in which all countries are seeking to chart the course of their future development. Contributing factors are the convergence of scientific and technological breakthroughs in the field of information technology, biotechnology and new materials with pervasive effects on all aspects of human endeavour; fundamental shifts in the nature of demand and in the shape and size of the market; and transformations in industry structure - at the firm level and in inter-firm relationships.

While having to respond to such pervasive changes can be a daunting, even frightening prospect, the reality is that this phase of change is not only creating challenges but also many opportunities for developing countries to gain benefits in the short and long-term - the availability of new equipment, new products and new services allows effective users to become more productive and more competitive; new markets have opened up for new products and services; new opportunities for learning have arisen; and in a general sense, massive R&D efforts worldwide are enlarging the pool of knowledge which developing countries can, in principle, draw on to solve their problems.

Change produces potential problems as well but the negative impacts can be greatly alleviated if countries are able to respond to the challenges in an appropriate and timely fashion.

There are many examples of developing countries' enterprises that have responded to the opportunities and challenges posed - starting from whatever problems they have; they have marshalled their resources, exploited their strengths and moved forward. This positive attitude and approach points the way ahead.

The critical issue confronting developing countries then, in this era of change, is how to respond to the opportunities and challenges they face.

Technology information

It is apparent that as yet there is a lack of full awareness of both the threat and, especially, the opportunities inherent in the new technologies. The effects of the new technologies can be direct, e.g. a rise in total factor productivity. They can also be indirect in that they enable the reaping of benefits of competitive advantage in other industries. These indirect effects should be recognized. This applies in particular to infrastructural investments, e.g. in telecommunications.

1/ In this chapter the conclusions and recommendations as adopted in the Meeting's final session and reflecting the discussions during the Meeting are reproduced.

The developed countries are now utilizing to an increasing extent the large potentialities that the numerically controlled machine tools and other technologies constitute. The developing countries, even the most advanced of those, are falling behind in this utilization. This development may lead to decreasing competitiveness in the field of metalworking and associated industries.

It is thus essential to enhance the diffusion of information not only about the technical aspects of new technology but also the conditions (e.g. industry structure) under which it is produced as well as its economic and social effects. Emphasis should be laid not only on threats but also on opportunities. The diffusion of information includes improving the South-South flow of information.

Some of the developing countries have already made considerable achievements in various segments of new technology. It would be essential for other developing countries to be informed of these capabilities in order to possibly utilize that know-how and experience for their own development.

The increased value of information in a world where changes are increasingly driven by new technology imply that the capabilities to analyze the relationship between technical and economic change has increased in value. Such analytical skills should therefore be fostered and more resources should be spent on both information gathering, analysis and diffusion. These analytical capabilities would tend to be embodied in persons with a multidisciplinary background.

Organizational innovation

As is generally recognized new forms of industrial production organization within the firm (e.g. just-in-time production and inventory control, total quality control and group technology), and new types of relations between enterprises (such as long-term comprehensive buyer-supplier contracts), are perhaps more important to improving firm competitiveness in the short run than the use of new technologies and are indeed essential preconditions to effectively apply the new technologies. So far developing countries seem to lag behind in implementing such organizational measures and need to explore these possibilities. The knowledge of these organizational innovations needs to be diffused among managers and engineers if relevant to conditions in developing countries.

Institutional change

Together with action to acquire the necessary scientific, educational and engineering skills, developing countries need to construct appropriate institutional and organizational structures to be able to successfully respond to the rapid, partly unpredictable changes that lie ahead in the 1990s. It is clear that the quantum leap in the science and knowledge content of production, and the speed of technical change necessitate a restructuring of the institutional setting.

The interdisciplinary approach required in materials, biotechnology and microelectronics development must increasingly be reflected in the organization of public administration and institutions. In place of vertical, hierarchical administrative structures, rigid delineation of functions and

compartmentalization of ministries and departments, what is required is (a) flatter, more flexible hierarchies and decision-making approaches and (b) horizontal co-ordination and integration of policy making and follow-up actions across several departments and ministries, in the areas of science and technology. Further, it follows that appropriate decision-making can only result from the employment of appropriate high-level interdisciplinary teams who can monitor, gather, and analyse data and information in advanced materials, microelectronics and biotechnologies, and translate them into appropriate domestic market opportunities, and relevant needs for education, training, research and specific manufacturing capacities or industrial uses. Moreover, horizontal integration of government departments should encompass co-ordination of high technology policy and research between government, industry and universities, a process already underway in developed countries. Correct policy formation and identification of trends within developing economies in the 1990s requires appropriate interdisciplinary teams within government institutions.

R&D infrastructure

Many research centres in developing countries are not fully and adequately utilized. In some cases the centres are deteriorating and are not living up to the expectations nor corresponding to the original high investment outlays. The upgrading of research centres, their rational interaction with their users and with policy-makers is essential. Proper financial arrangements (possibly through a special fund) would have to be made to ensure this upgrading. It is also essential that R&D activities within industrial companies be promoted.

Human resources

There is an increasing awareness that the education and skill level of the labour force largely determine a country's competitive strength and resilience, its capacity to adjust to new sophisticated technologies and to reduce the economic and social costs of the adjustment process. This has been a clear lesson from successful countries, both developing and industrialized. A cornerstone in their human resources development strategies have been efforts to organize an efficient country-wide vocational training system. Indeed, the quality of vocational training more than anything else is the decisive factor in coping with technical change and in applying new technologies. Even countries with a strong scientific elite will meet difficulties in diffusing new technologies unless they have given equal priority to their vocational training system.

The absence of adequately trained human resources is in many cases a major bottleneck for advancement in a number of high and new technology areas. Firstly, developing countries should therefore ensure that the existing scarce human resources are utilized in an optimal way. Secondly, human resources development should be specifically designed to enable and support the technology advancement. Multidisciplinary training for industry and decision-makers in government as well as financial institutions is essential. International co-operation in this field needs to be conceived both with industrialized and developing countries. Human resources development should thus be part of any industrial and technological co-operation. A systematic utilization of opportunities for training abroad

needs to be made. In doing so, it should be ensured that the trained personnel of developing countries are induced to return to their countries and apply their acquired knowledge in the specific fields of their expertise.

Financial resources

The requirements for scientific and technological progress in developing countries will place major financial burdens on these countries. Reform of the institutional set up, the conduct of R&D, the creation of appropriate infrastructure, the provision of required educational and training systems, and access to information and data will demand vast financial resources.

The question arises as to the mechanisms by which financial resources can be made available to meet these needs such as through commercialization of access to information, so that companies actually pay for the use of data and information. Another issue is that the banking system must increasingly become aware of new training, educational, scientific and industrial requirements and reorientate its priorities and expertise to meet these. Currently the banking and other financial sectors in many developing countries do not possess the resources, methodology, incentives, expertise and inclination to assess risk and allocate funds in these areas. Hence institutional change must also encompass financial intermediaries. The creation of a venture capital market may also assist in the channelling of funds into high risk new technology areas.

The large external debt and heavy debt servicing bu den of many developing countries constitute a major constraint to their industrial and technological development. In view of the foreign exchange scarcity of many developing countries, the increasing financial resources required for scientific and technological upgrading need enhanced involvement and support by international institutions. Ways must be found so that various international and regional banks and funds and UNIDO provide and/or promote financial support for material and non-material investment in the context of a strategy for science and technology for developing countries in the areas of advanced materials, microelectronics and biotechnology.

To this end, it is essential that the financial decision-makers be made fully acquainted with the international trends of technology development and the importance of this development for industrialization.

Acquisition of technology

Foreign collaboration is a key means for developing countries to obtain access to information and know-how in new technology. The modalities and policies to ensure local involvement, participation and further development are, however, crucial issues.

In the field of foreign direct investment in developing countries, far-reaching changes in investment motives and investment strategies are to be observed at present. Key determinants of what has become a thinner flow of foreign direct investment to developing countries are skill levels, market size, the existence of an efficient industrial support network, the availability and quality of a variety of support services as well as advanced telecommunication and information-processing facilities. Whereas previously a certain physical infrastructure (transport facilities, energy and water

supply) was often sufficient to attract foreign direct investment, now a highly developed human and technological infrastructure is required as well and is becoming increasingly important.

Foreign direct investment flows to developing countries thus may be expected to keep concentrating on only a few more advanced developing countries which meet the requirements outlined above while other countries will be left aside. Therefore special measures need to be designed for the least developed countries. Inter alia specific new technology joint ventures may be promoted and set up by investors from several developing and developed countries with support by international finance.

In negotiating and implementing foreign direct investment developing countries should ensure that local capa ilities be utilized to the maximum extent. Proposals for turnkey approaches should be carefully assessed. Local supplies, development of user skills, maintenance services, further upgrading of technology and components manufacture are the essential parts of a foreign direct investment deal for which local capabilities should be utilized.

Entry barriers

Several types of entry barriers are constraining the attempts of developing country firms to acquire new technologies in crucial areas such as microelectronics or biotechnology. Apart from financial barriers and barriers in the commercial scaling up of research results this relates increasingly to intellectual property rights. Patentability is being extended to new areas including newly created plants and biological organisms and increasing confidentiality is attached to R&D efforts and exchange of scientific information. While the extension of patentability may be generally conducive to innovation through greater appropriability of the commercial returns it can at the same time significantly constrain the access of developing countries to the technology areas covered by patent legislation. To overcome this barrier developing country firms may actively seek the establishment of joint ventures with foreign patent holding companies. Furthermore, developing countries should operate a patent system conducive to their level of industrial and technological development.

Other types of severe barriers of entry facing developing countries in new and high technologies are protectionism and practices of commercial retaliation in the current international trade system.

2. Recommendations

National level

1. In view of the need to increase the awareness of decision-makers in developing countries of technological developments, it is recommended that developing countries establish and further strengthen their capabilities to acquire, absorb and disseminate information from international sources on new and high technology and the impact on their industrialization prospects. These capacities would include monitoring and surveillance of key industrial technologies. They should also cover associated organizational innovations and changes in corporate structures and markets. The diffusion of such

information among the various agents of change in the economy should be ensured. This would involve the public authorities, R&D institutes, the industrial sector and the industrial enterprises.

2. Sector-specific technology information centres/councils covering key areas such as new materials technologies and automation technologies should be established. More specifically, in the area of advanced materials it is recommended that countries concerned should establish a Materials Council comprising an interdisciplinary team (e.g. physicists, chemists, metallurgists, ceramists) to monitor and interpret scientific and industrial trends, formulate relevant policy and co-ordinate its implementation across ministries, universities and industry. At the same time, where possible a Materials Science and Engineering Research Centre should be established on a national or regional basis for the provision of high-powered research teams, centralized research instrumentation and laboratory facilities, in-house training, conducting of research in the production and use of advanced materials, technological upgrading of traditional materials as well as gathering information, including through access to global data banks and formation of links with foreign research institutes and societies. Such a research centre would also enable developing countries to continue utilizing their traditional primary commodities (e.g. natural rubber, wood, cotton, bauxite, copper) by responding technologically, developing new uses and possibly facilitating a long-run transition to relevant advanced materials consistent with domestic resources. The establishment of similar research centres could be conceived for other important areas of new and high technology.

3. As an integral part of an industrial strategy and industrial technology development programme a restructuring of the institutional machinery needs to be pursued. It is recommended that policies be formulated to promote close interaction between the research, finance, administration and production sectors of a country.

4. The new technologies and organizational innovations put a premium on quick responses, flexibility and a high level of innovativeness and entrepreneurship in industry. Small- and medium-scale enterprises have often been found to excel in these respects. It is recommended therefore to strengthen their important role by providing a range of collective services in areas such as design capabilities, marketing and consultancy services. Close interaction between governments and industry associations in establishing such common services should be arranged.

5. It is recommended that a reassessment be made of current R&D facilities including research centres in individual developing countries so as to upgrade and make more efficient those existing facilities. In this context, the pooling of resources into science parks may warrant due attention.

6. Existing training and education institutions should be organized in such a way as to provide the skills necessary for technological change. New modes and modalities for interdisciplinary up-to-date training in selected fields of new technology need to be explored. This would include training abroad.

Regional level

1. It is recommended that developing countries explore the scope and modalities for launching specific industry-related technology programmes at the regional and subregional levels. Such endeavours may include co-operation agreements with corresponding schemes in other regional groupings in both developing and developed countries.

2. The recommended setting up of technology/sector-specific information centres at the national level should be combined with the establishment of regional/subregional networks through which such centres would be able to pool resources and information as well as to conceive joint programmes.

3. At the regional and interregional levels - with support of international organizations such as UNIDO - mechanisms should be established to ensure that developing countries be informed of specific advances in crucial technology areas in other developing countries.

International level

1. It is recommended that a series of regional workshops in Africa, Asia and Latin America and the Caribbean be organized by UNIDO as a follow-up to the recommendations pertaining to regional and subregional activities and programmes for the development of new and high technologies.

2. UNIDO should establish multidisciplinary programmes which would render support to developing countries in their efforts to develop new and high technologies. The programmes would embrace activities such as assistance in R&D, institutional infrastructure, training, promotion, negotiation etc. Through such programmes UNIDO could, inter alia, carry out inventories and assessments of relevant R&D programmes in individual developing countries and advise on measures to industrially utilize and commercialize the R&D results.

3. The establishment of an International Centre for Materials Science and Engineering which would act on behalf of developing countries was recommended. The Centre comprising an interdisciplinary team of high-level scientists and engineers, could perform several functions of critical importance to economic development in the 1990s such as: (a) undertake frontier research in all areas of materials science, (b) provide centralised research facilities and instrumentation (e.g. synchrotron radiation) for use by scientists and industry from developing countries; (c) collect data and information on new materials and their properties; (d) provide testing, standards, quality control and sensors, information and equipment necessary for materials processing and use; (e) provide training for nationals from developing countries; (f) establish contacts with the world scientific community and (e) formulate a materials policy relevant to specific economies. Such a Centre would be of special importance to countries which are currently facing severe constraints in scientific training and resources. UNIDO could assume a leading role in this endeavour.

ANNEX 1

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ANNEX 2

LIST OF PAPERS PRESENTED AT THE MEETING

1. Documentation prepared by the UNIDO Secretariat

Issue Paper

New Technologies and Industrialization Prospects for Develcping Countries. Main Policy Issues (prepared by the Regional and Countrv Studies Branch)

Technology Case Studies

No.1. Technological Change in Telecommunications. Implications for Industrial Policy in Developing Countries (prepared by Kurt Hoffman).

No. 2. Technological and Organizational Change in the Global Textile/Clothing Industry. Implications for Industrial Policy in Developing Countries (prepared by Kurt Hoffman).

No. 3. Industrial Applications of Biotechnology. Implications for Industrial Policy in Developing Countries (prepared by Martin Fransman).

No. 4. Technological Change in the Machine Tool Industry. Implications for Industrial Policy in Developing Countries (prepared by Staffan Jacobsson).

No. 5. Industrial Applications of New and Advanced Materials. Implications for Industrial Policy in Developing Countries (prepared by Lakis Kaounides).

2. Papers prepared by country experts

No. 1. Les incidences des mutations technologiques et des technologies de pointe sur l'industrialisation des pays en développement: l'expérience de l'Algérie (prepared by M. Hadjseyd)

No. 2. Competitive Integration. A New Strategy for Brazilian Industrialization (prepared by L.P. V. Lucas)

No. 3. L'évolution des techniques nouvelles et des technologies de pointe: l'expérience du Burkina Faso (prepared by M.B. Bado)

No. 4. L'évolution des techniques nouvelles et des technologies de pointe: l'expérience du Cameroun (prepared by E. Sikombe)

No. 5. La politica de transferencia de tecnología en Cuba (prepared by the Academia de Ciencia de Cuba)

No. 6. Perspectivas del desarrollo industrial en el Ecuador y grado de utilización de tecnologias avanzadas (prepared by L. Maldonado Lince)

No. 7. Technology Development in Egypt with Particular Reference to New and High Technology (prepared by A.W.S. Bishry)

No. 8. New Technologies and Policy Implications: The Case of Ethiopia (prepared by D. Assefa)

No. 9. The Diffusion and Impact of New Technologies in Ghana's Industrial Sector (prepared by E.P. Amonoo-Neizer)

No. 10. Diffusion and Impact of Advanced Technologies on India's Industrial Sector (prepared by H.C. Gandhi)

No. 11. Issues in the Industrial Application of New Technologies in Iraq (prepared by Y.Y. Shunia)

No. 12. Issues in the Industrial Application of New Technologies in Jamaica (prepared by W. Gooden)

No. 13. Industrialization and Technology in Jordan (prepared by M. Bani-Hani)

No. 14. The Impact of New Technologies in Malta (prepared by J.V. Bannister)

No. 15. La industrialización de México y las nuevas tecnologías (prepared by R. Villarreal Gonda)

No. 16. L'évolution des techniques nouvelles et des technologies de pointe: l'expérience du Niger (prepared by B. Dia)

No. 17. New and High Technology-based Industries in Thailand (prepared by Ch. Malaigrong)

No. 18. Problems and Prospects of Science and Technology in Viet Nam (prepared by Nguyen Phi Hung and Nguyen Trung)

3. Papers prepared by experts from regional/international organizations

No. 1. Present and Prospective Diffusion of Microelectronics, Telecommunications and Biotechnologies in the Industrial Sector of Western Asian Countries (prepared by K. Jabbar, ESCWA)

No. 2. Impact of Technological Change on Patterns of International Trade (prepared by T. Ganiatsos, UNCTAD)