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Discussion Paper

POSSIBLE ISSUES FOR THE FIRST CONSULTATION ON THE ELECTRONICS INDUSTRY*

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UNIDO Secretariat

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CONTENTS

I. INTRODUCTION

Although electronics technologies have their origin in the 19th and early years of the 20th century, it was the emergence of the semiconductor industry and the rapid technological achievements in semiconductor technology leading to, among others, the invention of the microprocessor in 1971, which ushered in the electronics revolution[1/]. The introduction of microprocessors made it possible to extend the use of computers to virtually all areas of economic activities including agriculture, industry and services. These computers are fundamentally altering the way economic activities are performed and this has far reaching implications on global development. A revolutionary restructuring of the economy has been set in motion as a consequence of the technological advances in electronics. The electronics industry has brought about improvements in productivity, quality and sophistication of products and services in the industrialized countries and this offers great potentials to the developing countries in their efforts to raise their share of global economic output for the economic benefits of their peoples.

The electronics hardware industry produces a very large variety of products which can be grouped into three sub-sectors namely: industrial electronics (for example computers, telecommunications equipment, industrial controls); consumer electronics (such as television, radio, video tape recorders); and components (resistors, capacitors, transistors, printed circuit boards, microprocessors).

Annex 1 shows the global 1986 production (excluding centrally-planned economies) of electronics hardware products. Out of a total production of $403 billion, the United States of America (U.S.A.), Japan and Western Europe accounted for over 90% of that total. Among the industrialized countries, the leading producers were the U.S.A., Japan and the Federal Republic of Germany with 43%, 22% and 6% of total global production respectively. Newly

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1/ For a comprehensive review of the electronics revolution see, for example, "Microelectronics and Society - A Report to the Club of Rome" by Guenther Friedrichs and Adam Schaff, published by Mentor (1983).

industrializing and developing countries with a significant presence in the market include the Republic of Korea, Singapore, Brazil, Hong Kong, India, Malaysia, Philippines, Thailand and Indonesia. Collectively these countries accounted for 7% of global output.

Globally, the industrial electronics sub-sector was the largest with an output of $265 billion (in 1986) representing 65.8% of the total industry output. The components sub-sector followed with $94 billion, equivalent to 23.4% of total output. Consumer electronics was the smallest sub-sector globally with $43.6 billion worth of output which was 10.8% of total output. Technologically, the industrial electronics sub-sector represents the high end of the technology spectrum followed by components (especially integrated circuits) and consumer electronics in that order. The sub-sectoral structural analysis indicates the general technological level of the industry in a particular country especially where the industry is exposed to international competition. From this perspective, it is observed from Annex 1 that in all the industrialized countries the subsectoral hierarchy in terms of value of production is in the order: industrial electronics - components - consumer electronics (albeit in varying proportions); reflecting the relatively high technological level of the industry in these countries. The situation in the newly industrializing and developing countries is quite different. With the exception of Hong Kong, components was the largest sub-sector in all the countries which adopted an export-oriented strategy in the development of their electronics industry. Such was the case for the Republic of Korea, Singapore, Malaysia, Philippines and Thailand. Countries which promoted the electronics industry largely on the basis of import substitution, such as Brazil and India, gave greater emphasis to industrial electronics and consumer electronics sub-sectors as compared to those countries whose industry is mainly export-oriented.

The largest exporter of electronics products in the world is Japan which in 1986 accounted for 25.3% of total world exports[2/]. The U.S.A. was second with an export share of 15.9% followed by the Federal Republic of Germany with 10.3%. Exports from the Asian countries (Singapore, Hong Kong and the

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2/ See UNIDO ID/WG.478/2 (SPEC.)II.

Republic of Korea) stood at 14.6% while that of Latin America was 1.6% In terms of imports, developing countries accounted for 23.6% of world total. This figure was higher for some classes of equipment like telecommunications where 33.2% of total world imports of $34 billion went to developing countries.

Annex 2 gives the global electronics hardware products market in 1986. The top 6 producers accounting for 82.6% of global production were also the top consumers with a combined share of 81.5% of the global market. Among developing countries, Brazil had the largest domestic market followed by the Republic of Korea.

As stated earlier, technology, especially semiconductor technology has been the main driving force for the electronics industry. The next section describes the technological evolution of the electronics industry and demonstrates the dramatic achievements and their implications.

II. TECHNOLOGICAL EVOLUTION OF THE ELECTRONICS INDUSTRY

Two main categories of electronics technologies may be identified, which have ushered in the electronics revolution. These are:

(i) Electronics technologies for information transmission; and

(ii) Electronics technologies for information processing.

It is the convergence of technological trends in the two categories that resulted in the rapid increase in applications of electronics technologies in society.

Technologies for information transmission

The art of information transmission has undergone several transformations from the time of the first demonstration of electrical telegraphy by Morse in 1843. Since then, driven by ever-increasing demand for more sophisticated long distance communication services, a number of historic milestones marking major
inventions with far reaching implications on the development of the industry may be identified. Among these, the following may be cited:

(i) The first submarine cable linking Calais in France and Dover in the British Isles in 1851;

(ii) The first transatlantic cable linking Europe and America in 1866;

(iii) The invention of the telephone by Alexander Bell in 1876;

(iv) The first demonstration of wireless telegraphy by Marconi in 1901.

With the above technological achievements, the stage was set for development of voice and data communication systems. Demand for these services rose dramatically especially for military and maritime applications. With rising demand, the capacities of the transmission systems were soon exhausted and new techniques had to be developed with larger information carrying capacities. This necessitated the development of transmission

systems operating at increasingly higher frequences. The original open wire and twisted pair copper transmission lines soon gave way to high capacity coaxial cables and, more recently, the introduction of optical fibers.

Similarly, in wireless communications, transmitting and receiving equipment were developed that operate over radio frequencies from the very low up to the microwave range. The requirements for wideband data communications systems and television broadcasting led to crowding of terrestrial wireless systems, and satellite transmission systems were developed to alleviate this problem by providing an alternative path of transmission through space. The use of satellite repeater stations in geostationary orbits, with associated earth stations, permitted global coverage between any two locations on earth.

Along with technological advances in increasing the capacities of information transmission systems, the type of information signal being transmitted has also been transformed. The continuing trend has been towards digital systems through conversion of analogue signals like those for speech and video to digital form. This trend has been inspired by the superior transmission performance of digital systems as compared to analogue systems. It is this trend towards digitization of wideband information transmission systems that has brought out a convergence of information transmission and processing technologies since the same technological trend occured in the latter. These developments have made it possible to effect direct communication between database systems through the telecommunication transmission system as both were then designed to handle similar signals. This has led to the development of local area networks linking a number of databases as well as provision of new value-added services, such as teletext and telefax.

The telecommunication networks of the future may be based on the concept of Integrated System Digital Network (ISDN) whereby all forms of signals, will be conveyed in digital form over the transmission network. Appropriate terminal equipment convert the digital signals into the desired form.

Technologies for information processing

With regard to information processing, several electronic devices and circuit systems have been developed. The first active electronic device was the vacuum tube diode used in signal detection developed by Fleming in 1904. Later in 1906, the vacuum tube triode with signal amplification capability, was introduced by Lee de Forest. These two basic electronic devices led to the introduction of regular radio broadcasting from the 1920s onwards. It is interesting to note that some of the current major multinational firms involved in the electronics sector, such as IBM (International Business Machines) were already in existence in those early days of the birth of the electronics era.

Several other electron tube devices were subsequently developed and these boosted developments in television broadcasting, telephone and telegraph services as well as a variety of consumer products. RADAR (Radio Detection And Ranging) was also introduced during this period along with the first generation of computers which were based on vacuum tube devices.

The vacuum tubes were bulky and inefficient. Thus the first computers developed in the 1940s were very large with only limited capabilities. The invention of the transistor by Stockley et al. in 1948 was one of the most important discoveries in the technological evolution of the electronics industry. Not only was the transistor much smaller than the vacuum tube, it soon proved to be more efficient and reliable. The invention of the transistor also gave birth to the semiconductor industry and these new electronic devices rapidly replaced the inefficient vacuum tubes in most electronic equipment. The second generation of computers were then based on the transistor.

Although the transition from vacuum tubes-based equipment to transistor-based equipment was very dramatic, with consequental restructuring of the entire industry, the demand for even more efficient, faster, smaller and highly reliable electronic systems persisted especially for military and space exploration programmes. The late 1950s saw the first introduction of integrated circuits whereby a number of circuit components were incorporated in a single silicon chip. Integrated circuits were used in the third

generation of computers introduced in the early 1960s. Since then the degree of integration has increased very rapidly from: small scale integration (SSI) to medium scale integration (MSI) to large scale integration (LSI) and currently to very large scale integration (VLSI).

With these technological advances, there has also been a tremendous reduction in the cost of integrated circuits measured in terms of functional capacities like memory or processing speed in MIPS (million instructions per second).

The invention of the microprocessor

The microprocessor was developed as a general purpose central processing unit on a single silicon chip, the specific function of which would be determined by the user through appropriate software. This development, along with achievements in LSI and VLSI technologies, led to new architectures of the fourth generation computers. With the increasing range of microprocessor applications, the cost of providing computing facilities dropped substantially and this resulted in the proliferation of personal computers among other developments.

Computers are diffusing rapidly in many industrial sectors. With regard to engineering industries, for example, several studies[3/] have confirmed the rapid rate of diffusion in industrialized countries of computer technologies, such as numerically controlled machine tools, computer-aided design and computer-aided manufacturing. The impact of this diffusion on employment, international competitiveness and prospects for continued industrialization in developing countries has also been analyzed. It is generally accepted that at the macroeconomic level the planned introduction of computers in industry has net positive effects and in many sectors it is essential for maintaining international competitiveness.

3/ See for example "Flexible Automation: The Global Diffusion of New Technology in the Engineering Industry" by Charles Edquist & Staffan Jacobson, Blackwell, 1988.

Computers handle information in digital form. The wide-spread use of computers, accompanied with the trend towards digitization of telecommunications transmission and switching systems, has resulted in a convergence of the underlying microelectronics technologies. This convergence has led to faster growth of the services sector in comparison to agriculture and industry and it is foreseen that the services sector may eventually be the dominant economic sector. Industrialization of developing countries will have to be advanced within this changed international environment characterized by the widespread application of computers linked through the telecommunication systems and a restructuring of the global economy. Development of appropriate strategies for developing countries requires careful planning so as to guide the application of the technology in the economy as well as induce local industrial expertise in the sector.

III. REGULATORY PROMOTIONAL ROLES OF GOVERNMENTS IN THE DEVELOPMENT OF THE ELECTRONICS INDUSTRY

(a) Industrialized Countries

Intrinsic characteristics of the electronics industry have attracted State intervention by many Governments of developed countries through public purchasing and other supportive measures. These Governments recognize the strategic importance of microelectronics-based products and services, especially their role in information handling and communications. The Governments have therefore strived to ensure that they have under their control adequate national capacities to develop and use this key technology.

The scale and economic importance of the electronics industry is also well established. Many see this growth sector as an area of opportunity and would wish to encourage the development of a national industry both for import substitution as well as exports. The beneficial results of the timely and appropriate use of electronics are of major importance. New products can be developed, and functionability, quality and reliability of existing products can be improved. The capability and reliability of industrial processes can be improved and their costs reduced. Overall, electronics can contribute significantly to increase the productivity and efficiency of an entire economy.

There is, in fact, a well developed practice of the Governments of developed countries using public purchasing to develop their electronics-based industries. It is, however, important to realize that, in most of the market-oriented economies, this activity has been in response to implicit rather than explicit Government policy - and indeed it is frequently seen to be at variance with stated Government policies. For this reason Government policy in this regard can better be inferred from concrete measures undertaken rather than an analysis of the stated policies themselves. It is, therefore, instructive to analyse a number of representative measures undertaken by Governments in developed countries so as to place in perspective the crucial role of state intervention in the development of the electronics sector.

Policy instruments that have been employed by Governments to influence development of the electronics industry have included a mix of the following:

- Support for research and development and training through grants, loans, etc.;
- Support for plant and equipment through provision of loans and grants;
- Government procurement;
- Regulation of the structure of the sector (e.g. encouraging mergers, anti-trust laws etc.);
- Foreign investments controls;
- Tariffs and trade policies.

In the United States, although a consistent and systematic set of policies directed towards this industry has not been developed, numerous Government measures have had direct or indirect effects on U.S. electronics firms. Throughout the 1950s and 1960s the Government stimulated developments in electronics by purchasing semiconductors for defence and space programmes as well as supporting R&D. The guaranteed market growths offered by these Government programmes were instrumental in establishing U.S. pioneering leadership in the industry. More recently U.S. Government support has sought to stimulate innovation through tax and regulatory reforms designed to improve the "climate" for innovation. Venture finance has been encouraged through successive reductions of the capital gains tax (1978, 1981). Other initiatives taken have included granting of increased tax credits for R&D, relaxation of anti-trust laws to allow for inter-firm cooperation in research and deregulation of the telecommunications industry aimed at minimizing institutional barriers to innovation. The U.S. electronics industry has also benefited from trade restrictions imposed on some semiconductor products in an attempt to reverse the increasing trade deficit of that country.

Development of the electronics industry in Japan has been favoured by the established system of promoting cooperation between the Government, Industry and Research Institutes, especially prior to commercialization of products. The Government has played a key role in formulating long-term plans for the sector as well as supporting numerous development projects. Examples of such projects are those dealing with VLSI Circuits, Robotics, Super Computers,

Fifth Generation Computers and Advanced Software. Invariably, Government support has been oriented towards facilitating the activities of industry as well as ensuring integrated and coherent development through coordination of activities. Public purchasing policies have also been pursued to promote Japanese electronics industries. Most influential in this regard has been the public telecommunications corporation Nippon Telegraph and Telephone (NTT) although there have been recent trends towards liberalization.

Similarly in Europe, Governments have intervened directly or indirectly to promote the electronics industry. Through support for national standards, for example, the telecommunications industry has often provided a protected domestic market for locally produced electronic equipment. In Western Europe, joint R&D programmes are being supported by Governments such as the ESPRIT programme. These programmes are aimed at advancing technological expertise in Europe so as to attain parity with the U.S.A. and Japan.

(b) Developing Countries

With regard to those developing countries that have achieved a perceptible presence in the global market, Governments have generally adopted either export-oriented strategies or import substitution.

Countries in which the export market has been the main driving force for the growth of the industry include the East and South-East Asian nations of the Republic of Korea, Singapore, Hong Kong, Malaysia, Philippines and Thailand. Development of the electronics industry in these countries followed some general pattern although the industry started at different times amongst them. Initially in the 1950s and 1960s the industry grew as import substitution for consumer products especially assembly of transistor radios. This activity was actively promoted by Governments through, for example, imposition of higher import tariffs on items like radios and televisions with much lower import duties levied on imported sub-assemblies.

In the 1960s many of these countries altered their strategies and decided to pursue an export-oriented labour intensive approach with a view to generate employment and improve their balance of payments. The electronics components

industry was particularly suitable to this approach since the downstream assembly operations in the production process were highly labour-intensive. During that period, some semiconductor multinational firms from the U.S.A., were seeking alternative sites away from the U.S.A. where labour costs were rising. These firms were facing increasing pressure from Japanese companies in the international market, and they decided to relocate the low skill labour- intensive assembly operations in some of the East and South-East Asian countries. The main motivation for this strategy by the multinational firms was to secure international competitiveness of their products through exploitation of cheap abundant labour available in that region.

In addition to providing cheap labour to the multinational firms, Governments, in due course, provided several other incentives to attract this form of foreign investments. Among such incentives may be mentioned the following: extended period tax holidays, duty free importation of capital goods and raw materials, free repatriation of profits, operation in free trade zones equipped with well developed infrastructure (e.g. electricity and telecommunication facilities), flexible labour laws and relaxation of Government control procedures with regard to foreign investments.

With the emergence of the multinational firms in the electronics industry scene, the sub-sectoral structure of the industry in these countries tilted in favour of the components sub-sector. Exports of electronics products rose rapidly and by 1985 the ratio of exports to total production was in the range between 60% to 97%[4/]. The growth of exports is demonstrated by the case of Malaysia where the ratio of export to total production rose from 9% in 1973 to over 85% in 1985.

In recent years there has started a new restructuring of the electronics industry in these countries. This followed currency appreciation in Japan and the Republic of Korea. Firms from these countries, led by Japan, have begun to relocate for export the assembly of consumer electronics products in

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4/ See UNIDO ID/WG.478/3 (SPEC.)

countries, such as Singapore, Thailand and Malaysia. This form of delocalization is seen to be potentially beneficial to the host country as it may lead to development of subcontracting activities. Such was not the case, in general, for assembly of components. Even then the level of technology transfer is still expected to be limited since the multinational firms still tend to locate the research and development facilities in their own countries. A recent exception is the establishment of a research centre in Thailand by a Japanese firm.

The involvement of multinational firms in the development of the electronics industry in the region has taken many forms. The main ones are direct investment, joint ventures, licensing and second sourcing agreements. Whereas Japanese firms have tended to conclude joint venture agreements, this has not been the case with firms from the U.S.A.

The Government of the Republic of Korea actively promoted joint ventures especially after 1973 within articulated policies coordinated by the State. The Republic of Korea has now established itself as one of the major producers of electronics products in the world. In 1986 this country ranked seventh in world production and advanced to the sixth position in 1987. Parallel to these developments has been the emergence of large Korean conglomerates capable of competing in the international market. This phenomenal success of the Korean electronics industry over a span of some 30 years has been largely due to elaborate sectoral development plans formulated by the Government coupled with economic and political support from leading technology suppliers enjoyed by that country. The Government declared the industry to be strategic and provided preferential treatment to encourage local investors and joint ventures. Research and development was supported through Government funding and close cooperation was forged between the Government, research institutes and industry; much along the pattern of Japan.

The success of the export-oriented strategy in the other South-East Asian countries has however not matched the Korean performance. Aside from the different socio-political contexts, a number of additional constraints have presented themselves and among these are:

(i) Over dependency on the multinational firms has resulted in increased vulnerability of the growth of the industry on the global corporate strategies of these firms. These global strategies may not necessarily be in harmony with the development needs of the host country. Local firms have tended to be small and mainly involved in the assembly of consumer electronics products for the domestic market. The technological level of these local firms has tended to be much lower than the state-of-the-art and thus further reducing their capacities to participate in the export market.

(ii) Many multinational firms operate in free trade zones and as such there has been little, if any, substantive linkage between the activities of these firms and those of the local firms. In particular subcontracting arrangements could not be easily organized. This situation has been particularly acute in Malaysia where the foreign firms have concentrated on components production primarily for the export market independently from the local firms engaged in assembly of consumer electronics for the domestic market although the latter obtain some of their components requirements from the multinational firms.

(iii) Despite the fact that foreign firms have, and continue to be, major employers in the South-East Asian countries, the skill level involved has remained generally very low. Only in a few of these countries has a degree of skill upgradation been achieved through inclusion of higher technology activities, like testing and wafer processing.

(iv) Research and development activities have continued to be undertaken by the multinational firms in the home country facilities. Virtually no R&D activities are undertaken by subsidiaries of multinational firms located in these developing countries.

With regard to import substitution, countries that have followed this approach in the development of their electronics industries are mainly those with large potential domestic markets. Of these, Brazil, India and Indonesia have achieved international levels of production although to varying degrees of success. In Brazil (population about 140 million), which ranked 12th in global production in 1986 at an output of $ 5.145 billion, the domestic market in the same year was $ 5.048 billion indicating a small positive trade balance of $ 97 million[5/]. India (with a population of about 750 million) produced electronics goods valued at $ 2.584 billion and consumed goods worth $ 2.657 billion yielding a small negative trade balance of $ 73 million. Performance of the local industry in Indonesia (population about 170 million) was relatively less impressive. In 1986 local production stood at $ 675 million while the domestic market was $ 907 million. The negative sectoral trade balance of $ 232 million represented 34 % of domestic production while the comparative figure in the case of India was only 2.8 %.

The negotiating capacities for importation of electronics technologies of the countries that have pursued the import substitution strategy has been strengthened by their large domestic markets. Governments, especially in Brazil and India, have actively intervened in the promotion of the sector. Local manufacturers have received preferential treatment and protection from competition by multinational firms. Tax incentives and special lines of credit have been made available to local investors and foreign firms have been urged to increase the level of local content in their products and to utilize local subcontractors. Policies and institutional arrangements for the promotion of the sector were developed. In the case of India, for example, the Department of Electronics was established in 1970 followed by the Electronics Commission in 1971. These two were established to provide focal points for planning integrated development of electronics. The Government of India also formulated regulatory and promotional policies such as the Policy on Industrial Components in 1981 and the Integrated Policy Measures of 1985.

5/ See UNIDO ID/WG.478/2 (SPEC.)

Corresponding developments in the case of Brazil were the promulgation of the Informatics Law of 1984, issuance of the sectoral plan a year later and establishment of public institutions such as SEI (Secretaria Especial de Informatica) and CONIN (Conselho Nacional de Informàtica and Automacao).

Comparison of the sub-sectoral structure of the electronics industry in the countries that followed import-substitution strategy with those that adopted export-orientation, reveals some basic differences. In Brazil and India, industrial electronics has been given the highest priority accounting for 52% and 46% of output in 1986, respectively. The components sub-sector is dominant in Indonesia as in the other South-East Asian countries which followed an export-oriented strategy. The components sub-sector is heavily controlled by the large semiconductor multinational firms many of which settled in South-East Asia, including Indonesia, for their strategic reasons.

The majority of the remaining developing countries are largely users of electronics products. A few of these countries have established modest assembly facilities for consumer electronics and telecommunications equipment. Many are faced with problems of repair and maintenance, lack of technological expertise and the consequent haphazard introduction of the technology into their economies. The limited domestic market, high technological level of the industry, rapid technological obsolescence, global control of the international market by multinational firms, high cost of R&D activities, shortage of resources (trained manpower and financial) and difficulties in attracting foreign investments present near formidable barriers to new entrants into the sector. The conditions which led to the growth of offshore assembly operations in South-East Asia are largely no longer applicable, especially with technological advances in factory automation which have reduced the labour cost component in production costs. Yet the electronics era has begun and all developing countries including those with no electronics production facilities will be affected by these developments through interaction with other countries via, for instance, importation of capital goods imbedded with a high degree of microelectronics technologies and international telecommunication services. For these

countries involvement in the electronics sector may require various levels of sub-regional and regional co-operation both at the R&D stage and for design and manufacturing. In addition, the countries may need to undertake measures for strengthening negotiating capabilities in the acquisition of electronics products so as to reverse the adverse consequences of indiscriminate importation of microelectronics-based technologies.

IV. SOFTWARE INDUSTRY; APPROACHES TO ITS DEVELOPMENT

The software industry is comprised of software suppliers, software products and human and physical resources related to software production. Major software suppliers include computer hardware manufacturers, specialized software houses and user companies. An emerging new class of software suppliers are companies engaged in telecommunications, semiconductor manufacturing and publishing. Software products may be classified according to use or product type or type of hardware on which it runs. On the basis of use, two classes of software products are identified: systems software which aids programmers through controlling internal hardware systems and applications software used to undertake specific user tasks, such as computer-aided manufacturing. Classification according to product type divides software into packaged software, custom software and integrated system software, whereas that according to type of hardware on which it runs, draws distinction between software for mainframes, mini and microcomputers. Main resources required in software production include skilled manpower - especially system analysts and computer programmers, software development tools, such as program editors as well as computer hardware.

The software production process is a succession of different stages requiring differentiated skills, methods and techniques. The stages are broadly grouped into system definition; programming: testing and debugging; maintenance and enhancement. Among these production stages, the last one is an integral part, continuously adapting software to new needs and situations. The importance of this stage was demonstrated in a recent study of the industry in OECD countries[6/] wherein it was estimated that about 75 per cent of computing resources for 1980 in the United States were taken up by maintenance and enhancement activities. This observation, along with the labour-intensive nature of the software industry, has direct implications for developing countries in their use of computers for economic development.

6/ OECD, Software: An Emerging Industry, 1985.

The wide range of software products' diversity in users and difficulties in estimating the value of in-house software production have led to widely varying figures for worldwide software market estimates. Thus, for instance, estimates for the worldwide software market in 1986, range from $45 billion to $100 billion in purchases and development expenses[7/]. Forecasts of the global software market in the year 2000 range from $80 billion to $200 billion[8/].

Major trends in the global software market may be summarized as:

(a) Wider acceptance of packaged software;

(b) Growing demand for personal computer (PC) based software;

(c) Widening user base;

(d) Emergence of software support markets;

(e) Rapid growth in the market for artificial intelligence.

Along with increases in the sales of packaged software, the portion of PC-based software is projected to rise from 15 per cent in 1982 to over 25 per cent in 1991. This increase is mainly due to the widespread use and increasing capacity of microcomputers. Software houses are playing an increasingly leading role in production of packaged software. A regional production structure has also emerged. While the United States account for over 70 per cent of the global packaged software production, software companies in France, Japan and other industrialized countries have tended to concentrate on custom software[9/]. In terms of overall consumption, many countries show an increasing proportion in consumption of packaged software.

7/ ADB, Business Week, March 2, 1987 and Computer Design, Jan. 1, 1987.

8/ ADB, Technical Assistance Study at Selected Industries, Vol. 4 (Computer Software) 1987.

9/ Electronics Industry Association of Korea Yearbook (1986).

The growing demand for PC-based software is due to the increasing use of personal computers worldwide. As of mid-1987, the IBM-PC and its clones numbered over 10 million units in the U.S. alone with at least half as many in the rest of the world. The market for PC-based software is expected to grow at an average rate of 30 per cent and reach about $45 billion by 1990[10/]. Technical advances in hardware systems coupled with the trend towards low-priced packaged software, have contributed significantly in widening the user base for computer systems. Many small business firms have installed computing facilities, although they invariably rely on external service companies for software products and maintenance. This latter aspect has led to the emergence of a software support market. User organizations contract with software suppliers or other independent parties for technical support of software packages. As computers became more widely used and software increasingly sophisticated, demand for this type of service is growing rapidly. Lastly, the market for artificial intelligence is expected to increase at an annual rate of 29 per cent according to MIS Week (Feb. 9, 1987). A major portion of this increase will be due to developments in expert systems whereby the U.S. market is forecast to rise from $500 million in 1986 to $1800 million in 1990.

A degree of specialization has developed among the major software suppliers. Hardware manufacturers tend to concentrate on system software and general purpose application software, such as accounting, management and payroll. On the other hand, software houses are primarily producing packaged software (especially PC based) and custom software for specific applications. Trends in in-house software development among users have shown increasing concentration on maintenance and enhancement activities. Overall the software market is intrinsically linked to technological developments in computer hardware and architecture as well as capabilities of system analysts and programmers.

10/ ADB, 1987.

Technologically, the software industry has advanced extensively, although due to its labour and skill-intensive nature, this has not matched developments in computer hardware. In the 1950s and up to the early 1960s, software was written by specialists using machine and assembly languages. High-level languages like FORTRAN, COBOL and ALGOL came into use in the late 1960s. Ordinary computer users (non-specialists) were then able to write programs using the high-level languages. As complexity of software increased, the cost of software development rose prohibitively and this led to the demand for standardized application packages and general purpose operating systems. Establishment of database systems in the 1980s, along with advances in communications networks and limitations of large central processing systems created a demand for distributed computing. New software systems had to be developed to cater for parallel information processing and this continues to be an area of intensive research. Significant improvements in productivity and reliability of software products are also being realized following advances in software engineering technology. Future software products will include an increasing share of firmware, whereby software of diverse variety is imbedded in a single chip.

Software industry in developing countries

The software industry in developing countries is either totally non-existent or at its embryonic stage. This span of development of the industry ranges from budding software firms in the more advanced developing countries, such as India, Brazil, Singapore and the Republic of Korea to the majority of developing countries who import virtually all their software requirements. Many of the latter group of countries re., totally on foreign firms with regard to software maintenance and enhancement activities as well. Nonetheless, the fact that the software industry is labour intensive, albeit highly skilled, has attracted many development planners to assess the opportunities and constraints of developing this industry in developing countries.

Consideration of conditions generally prevailing in developing countries reveals a number of constraints which may retard or discourage development of a local software industry. One such constraint arises from the limited

domestic market. The market for software products is intrinsically linked to utilization of computer hardware equipment. The relatively low level of use of computers in developing countries limits the size of the potential domestic market upon which the software industry could build upon. A second constraint relates to scarcity of skilled software specialists, such as system analysts and programmers. Those specialists that may be available, often have little opportunities to keep up with state-of-the-art technological expertise in addition to lacking adequate software development tools. Yet another constraint prevalent in developing countries relates to inadequate infrastructure development needed to support the industry. This includes lack of product standardization and underdeveloped telecommunications, marketing and distribution systems, as well as low level informatization of socio-economic systems.

These domestic constraints also have negative implications on prospects for exporting software products into the highly competitive international market. The language barrier in the international market, whereby most software is written in English (on account of the U.S. dominance in this industry), may also hinder development of export-oriented software industries in non-English speaking developing countries. In spite of these constraints, some developing countries, especially those with large populations and solid education systems, foresee opportunities of exploiting their manpower resources in establishing software industries. These countries also see the need to develop software products based on local languages and compatible to the local socio-economic activities and practices. For other developing countries where it may not be feasible to develop a full-fledged local industry involved in the complete spectrum of software development activities, development of indigenous expertise in software maintenance and enhancement is considered crucial in optimizing the benefits of computer applications in the economy. The increasing cost of maintenance and enhancement of internationally available software systems have led to a growing demand for software support services in virtually all countries. Based on these aspirations, some general strategies, and policies that may promote development of the software industry in developing countries may be elaborated.

As with the electronics hardware sector, the role of the Government in promoting a local software industry is fundamental. Since the industry is still in its infancy or even non-existent in most developing countries and since the international market is extremely competitive, it appears that a domestic-oriented development of the industry may be the most viable approach for these countries to enter and sustain development of the software sector. Such a strategy, however, would require an active role on the part of the Government in adopting measures to expand the market. These measures may include:

- Formulation of favourable Government procurement policies;
- Promotion of standardization in computer hardware and software products;
- Promotion of use of computers in all economic sectors through, inter alia, provision of favourable conditions for capital expenditures involving computers;
- Promotion of technological development by creating a conducive atmosphere for establishment of joint ventures, licensing arrangements and basic research and developments in cooperation with software suppliers in developed countries;
- Encouraging institutions of higher learning as well as vocational schools to develop suitable training programs in Computer Science, Electronics and Management Science;
- Preferential treatment of local software firms through provision of incentives.

With regard to exports, only a selective niche-oriented approach appears feasible for those countries that have acquired international level expertise in specific software products. Already some developing countries have been able to export some software products. In some cases firms in developing countries have sought certification of their software specialists from institutions in industrialized countries, notably the United States, in a bid to acquire international acceptance of the quality and reliability of their software products.

V. FINAL CONSIDERATIONS

In the light of the global scenario described above, the UNIDO Secretariat proposes that the issues for the First Consultation on the Electronics Industry be selected from the following:

(i) Strategies for Integrated Development of the Electronics Industry

a) Export-orientation

There is a need to critically analyze the export-oriented and import substitution strategies that were adopted by various developing countries in the development of their electronics industries and, from this, to propose appropriate strategies for new entrants and those likely to remain mainly users of electronics products in the foreseeable future.

With regard to countries that followed export-oriented strategies, it would appear that future development strategies should address problems of structural deficiencies, low technological levels, limitations of domestic markets and heavy reliance on foreign investments. There is a need to restructure the industry which in many of these countries is heavily skewed towards the components sub-sector. The components sub-sector, especially that of semiconductor components, is strongly influenced by large multinational firms with global corporate development strategies that may not necessarily be in harmony with the development objectives of individual host countries. Furthermore, semiconductor components production demands large economies of scale which in turn calls for high capital investments. Obsolescence in semiconductor technology occurs very rapidly and only the major multinational firms have the resources needed to invest in leading edge research and development activities.

Ample opportunities do however exist for development of consumer electronics and industrial electronics sub-sectors. The domestic market, through appropriate government promotional measures, may form the initial basis for the development of these sub-sectors. Linkages between the sub-sectors should be established along with promotion of critical supplier and support industries.

Technological upgradation requires introduction of products of progressively more sophisticated design and engineering as well as improvement of existing manufacturing processes and integration with upstream and downstream manufacturing. This technological upgradation should have a strong local foundation through creation of local expertise in design and engineering. Governments may wish to provide incentives for increasing local value added of products and for investments in research and development.

It appears that joint ventures and licensing arrangements (original equipment manufacturing or second sourcing) with local firms, have been effective instruments in the transfer of technology in the electronics industry. This strategy has been fairly successful in the Republic of Korea and is increasingly sought in other countries as well.

b) Import substitution: large markets

Countries that adopted an import substitution approach in building up their electronics industries have generally emphasized the industrial electronics and consumer electronics sub-sectors. However, this approach has tended to be effective mainly in countries with protected large domestic markets. Major development constraints include limited capabilities in research and development, difficulties in acquiring state-of-the-art technologies and hence a generally lower technological level of their products. There are also problems emanating from lack of appropriate linkages with other sectors with the result that a coherent productive system has not been achieved. In these countries, programmes for enhancing close co-operation between research institutes, industry and the Government may be indispensable in providing the needed upward thrust to the industry. To ensure reliability and cost effectiveness of the industry, suitable export market niches should be identified so as that local industry may benefit from the experience of the international market, and regional and/or sub-regional cooperation programmes may be required so as to optimize resource utilization.

c) Import substitution: Small markets

For new entrants and those likely to remain mainly as users of electronics products relevant developmental considerations relate to suitable programmes for developing expertise in:

- repair and maintenance of electronic equipment;
- selection and development of suitable microelectronics application systems including computers;
- design and engineering of simple electronic equipment for the domestic market;
- assembly and testing of simple consumer and industrial electronics equipment (especially telecommunications equipment, personal computers) using imported sub-assemblies and components; and
- electronics, computer and management sciences.

Attainment of the above shall necessarily call for appropriate Government intervention in the way of formulation of the policies, programmes and provision of incentives as appropriate. The basic developmental approach would seem to be a selective domestic market-oriented strategy coupled with measures for expanding the domestic market so as to permit the economy to benefit from the technological advances in microelectronics. Few of the countries in this category may still be able to attract new foreign investments in offshore operations but it is to be noted that foreign investors in this sector are increasingly demanding lucrative incentives especially with regard to infrastructure developments, tax holidays, relaxed labour laws (including safety regulations that would not be acceptable in their own countries), guaranteed repatriation of profits and generally minimal government controls on their operations. While these forms of investments may generate employment and contribute towards foreign exchange earnings, their developmental impact requires careful examination. For certain country groupings, regional and/or sub-regional development programmes for the sector may also be feasible as a way of pooling resources.

(ii) Electronics technologies in the service of development

The role of technology in economic, social and political developments, both within national and international contexts, is now widely recognized. Technological changes deeply affect the worldwide distribution of productive facilities and services.

Early technological advances in textile manufacture, for example, fundamentally altered the global structure of the industry. By the 1980s the price of yarn was of the order of one twentieth of what it had been some 50 years earlier[11/]. The consequence of this was that labour-intensive production facilities in countries like India, in which textile manufacture was a major industry, could no longer compete either in quality or quantity in the international market. Likewise, development of synthetic fibres in the 1960s led to the virtual extinction of the sisal industries in Mexico and Tanzania which between them formerly supplied almost the entire world demand for such fibers.

The above technological advances affected mainly specific economic sectors. The impact of microelectronics is much more far-reaching than those cited above since the underlying technology is rapidly diffusing into all economic sectors. Among the implications of this diffisuion on developing countries, the following may be mentioned:

a) Traditional industries such as iron and steel and non-ferrous metals including downstream facilities for production of finished and semi-finished products are moving towards the high technology category.

b) Decisions to locate manufacturing facilities in developing countries are increasingly based on provision of major concessions and special arrangements by host Governments.

c) The trend in the incorporation of functions previously performed by mechanical or electromechanical systems into electronic components has the effect of increasing the packaging of technology into "black boxes". Technology unpackaging as a strategy for technology absorption and development will become more difficult.

11/ See "Microelectronics and Society. A Report to the Club of Rome" by G. Friedrichs and A. Schaff, Mentor (1983).

This issue could analyze the consequences of the above trends with a view to assess critically the potential impacts on the global structure of industry brought about by electronics technologies.

(iii) Approaches to software development and financing problems

a) Promotional measures

Software costs now account for the larger share in the purchase of electronic systems. Within the software industry, there is an increasing trend towards standardization through provision of application packages and standard operating systems. The cost for maintenance and enhancement of these software products is increasing rapidly and development of expertise in this area appears to be generally applicable for all countries utilizing computers.

Development of the local software industry requires Government support in expanding the domestic market through encouraging the use of computers and offering incentives to local entrepreneurs. For some countries, it may be feasible to develop software systems based on local languages if the domestic or sub-regional market is large enough. In all cases, co-operation with major hardware suppliers and software houses in industrialized countries is essential for development of the local software industry. The personal computer market appears to be a suitable entry point for newcomers. At the national level, suitable training programmes to increase computer literacy are required so as to ensure greater appreciation of computing power, identification of new applications and development of appropriate systems.

b) Financing

Financing of software development poses special problems particularly due to the intangible nature of software products. Despite notable achievements in computer-assisted software engineering, the software industry remains highly skill- and labour-intensive. Thus, investment in labour constitutes a large proportion of the overall costs of software development projects. Where the industry has thrived, such as in Silicon Valley in the U.S.A., these projects have been undertaken typically by small firms many of which could not

fulfil the standard investment criteria of commercial lending banks. The development and maturity of the venture capital market in the U.S.A. has been critical in sustaining development of the industry in that country. Elsewhere in Western Europe, the venture capital market is still at an embryonic stage. However, most Governments have provided direct financial support to encourage software development.

Development of local software houses in developing countries shall therefore require establishment of special lines of credit. In addition, financial incentives will be required to encourage investments in this industry. The role of Governments is crucial since financing of software projects from commercial and development projects may be difficult especially in the formative years.

Annex 1 - Global 1986 Production

Source: UNIDO ID/WG.478/2 (SPEC.)

Country	Industrial Electronics $ millions and % of total country production in (.)	Consumer Electronics $ millions and % of total country production in (.)	Components $millions and % of total country production in (.)	Total country production in $ mill. and % of global production in (.)	Rank in global production
United States of America	134.867 (77.48)	6.106 (3.51)	33.094 (19.01)	174.067 (43.22)	1
Japan	41.213 (46.04)	20.402 (22.79)	7.909 (31.17)	89.524 (22.23)	2
Germany, Federal Republic of	17.623 (70.76)	2.361 (9.48)	4.922 (19.76)	4.906 (6.18)	3
United Kingdom	14.206 (77.68)	956 (5.23)	3.125 (17.09)	18.287 (4.54)	4
France	12.899 (76.47)	797 (4.73)	3.171 (18.80)	16.867 (4.19)	5
Italy	7.995 (81.34)	545 (5.54)	1.289 (13.12)	9.829 (2.44)	6
Republic of Korea	2.200 (28.10)	2.430 (31.04)	3.199 (40.86)	7.829 (1.94)	7
Taiwan, Province of China	1.938 (30.43)	1.667 (26.17)	2.764 (43.40)	6.369 (1.58)	8
Singapore	1.744 (31.15)	877 (15.67)	2.977 (53.18)	5.598 (1.39)	9
Canada	4.232 (78.64)	329 (6.11)	821 (15.25)	5.382 (1.34)	10

Country	Industrial Electronics $ millions and % of total country production in (.)	Consumer Electronics $ millions and % of total country production in (.)	Components $ millions and % of total country production (.)	Total country production in $ mill. and % of global production in (.)	Rank in global production
Netherlands	3.830 (72.7)	220 (4.18)	1.218 (23.12)	5.268 (1.31)	11
Brazil	2.673 (51.95)	1.162 (22.58)	1.310 (25.46)	5.145 (1.28)	12
Hong Kong	1.627 (41.75)	1.428 (36.64)	842 (21.61)	3.897 (0.97)	13
Sweden	2.983 (83.20)	126 (3.51)	476 (13.28)	3.585 (0.89)	14
Switzerland	1.891 (54.95)	1.078 (31.33)	472 (13.72)	3.441 (0.85)	15
Ireland, Republic of	2.136 (77.73)	21 (0.76)	591 (21.51)	2.748 (0.68)	16
Spain	1.902 (72.29)	412 (15.66)	317 (12.05)	2.631 (0.65)	17
India	1.185 (45.86)	936 (36.22)	463 (17.92)	2.584 0.64)	18
Benelux Countries	1.712 (68.45)	401 (16.03)	388 (15.52)	2.501 0.62)	19
Malaysia	270 (12.24)	231 (10.48)	1.704 (77.28)	2.205 (0.55)	20
Philippines	140 (10.12)	68 (4.92)	1.175 (84.96)	1.383 (0.34)	21
Austria	635 (50.92)	262 (21.01)	350 (28.07)	1.247 (0.31)	22

Country	Industrial Electronics $ millions and % of total country production in (.)	Consumer Electronics $ millions and % of total country production in (.)	Components $ millions and % of total country production (.)	Total country production in $ mill. and % of global production in (.)	Rank in global production
Israel	935 (78.97)	21 (1.77)	228 (19.26)	1.184 (0.29)	23
Denmark	886 (75.99)	88 (7.55)	192 (16.46)	1.166 (0.29)	24
Australia	873 (77.33)	141 (12.49)	115 (10.18)	1.129 0.28)	25
Finland	766 (71.12)	166 (15.41)	145 (13.37)	1.077 (0.27	26
Norway	830 (93.47)	11 (1.24)	47 (5.29)	888 (0.22)	27
Thailand	156 (20.39)	159 (20.78)	450 (58.82)	765 (0.19)	28
Indonesia	262 (38.81)	115 (17.04)	298 (44.15)	675 (0.17)	29
South Africa	399 (73.08)	86 (15.75)	61 (11.17)	546 (0.14)	30
World Total	265.008 (65.80)	43.602 (10.83)	94.113 (23.37)	402.723	

Annex 2 - Global Electronics Products Market (1986)

Source: UNIDO ID/WG.478/2 (SPEC.)

Country	Industrial Electronics in $ mill. and % of country market in (.)	Consumer Electronics in $ mill. and % of country market in (.)	Components in $ mill. and % of country market in (.)	Total country market in $ mill. and % of global market in (.)	Rank in global market
United States of America	129198 (69.42)	19300 (10.37)	37621 (20.21)	186119 (47.95)	1
Japan	28463 (51.66)	6615 (12.01)	20013 (36.33)	55091 (14.19)	2
Germany, Fed.Rep.of	16336 (67.76)	2490 (10.33)	5284 (21.91)	24110 (6.21)	3
United Kingdom	14982 (69.25)	2306 (10.66)	4346 (20.09)	21634 (5.57)	4
France	12963 (73.07)	1617 (9.11)	3161 (17.82)	17741 (4.57)	5
Italy	8892 (74.28)	1179 (9.85)	1900 (15.87)	11971 (3.08)	6
Canada	6029 (68.01)	1211 (13.66)	1625 (18.33)	8865 (2.28)	7
Netherlands	4218 (70.27)	640 (10.66)	1145 (19.07)	6003 (1.55)	8
Brazil	2641 (52.32)	1113 (22.05)	1294 (25.63)	5048 (1.30)	9
Rep.of Korea	2145 (44.33)	722 (14.92)	1972 (40.75)	4839 (1.25)	10
Spain	2929 (68.31)	734 (17.12)	625 (14.57)	4288 (1.10)	11
Sweden	2587 (65.91)	334 (8.51)	1004 (25.58)	3925 (1.01)	12
Taiwan - Prov. of China	974 (26.11)	584 (15.66)	2172 (58.23)	3730 (0.96)	13

Country	Industrial Electronics in $ mill. and % of country market in (.)	Consumer Electronics in $ mill. and % of country market in (.)	Components in $ mill. and % of country market in (.)	Total country market in $ mill. and % of global market in (.)	Rank in global market
Australia	2444 (69.75)	583 (16.64)	477 (13.61)	3504 (0.90)	14
Switzerland	2356 (68.31)	381 (11.05)	712 (20.64)	3449 (0.89)	15
Norway	1603 (46.64)	162 (4.71)	1672 (48.65)	3437 (0.89)	16
Benelux	2397 (73.68)	290 (8.92)	566 (17.40)	3252 (0.84)	17
Singapore	1256 (42.70)	485 (16.48)	1201 (40.82)	2942 (0.76)	18
India	1201 (45.20)	778 (29.28)	678 (25.52)	2657 (0.68)	19
Hong Kong	728 (30.69)	401 (16.91)	1243 (52.40)	2372 (0.61)	20
Austria	1289 (68.27)	240 (12.71)	359 (19.01)	1888 (0.49)	21
Ireland	1037 (61.36)	71 (4.20)	582 (34.44)	1690 (0.44)	22
South Africa	1320 (78.29)	152 (9.02)	214 (12.69)	1686 (0.43)	23
Finland	1083 (66.65)	188 (11.57)	354 (21.78)	1625 (0.42)	24
Denmark	1089 (67.39)	176 (10.89)	351 (21.72)	1616 (0.42)	25
Israel	1049 (73.25)	58 (4.05)	325 (22.70)	1432 (0.37)	26
Malaysia	685 (55.74)	200 (16.27)	344 (27.99)	1229 (0.32)	27

Country	Indust Electro.. s in $ mill. and % of ccuntry market in (.)	Consumer Electronics in $ mill. and % of country market in (.)	Components in $ mill. and % of country market in (.)	Total country market in $ mill.and % of global market in (.)	Rank in global market
Indonesia	510 (56.23)	203 (22.38)	194 (21.39)	907 (0.23)	28
Thailand	453 (59.68)	182 (23.98)	124 (16.34)	759 (0.20)	29
Philippines	201 (55.52)	59 (16.30)	102 (28.18)	362 (0.09)	30
Total	253058 (65.19)	43454 (11.20)	91660 (23.61)	388172	