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THE ELECTRONICS SECTOR*

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PREFACE

The creation of the European Single Market is the most significant step in economic integration so far taken. The creation of a single economic area in which capital and labour, goods and services all move freely is the target set by the countries of the European Community to be achieved by the end of 1992. Given the size and strengths of the Community, the changes under way may be expected to have significant impacts beyond its borders.

UNIDO, with financial support from the Government of the Netherlands, is holding an Expert Group Meeting to examine the main implications of this process for industrialization in developing countries. The expected growth effects of the Single Market will have implications for the world economy, including changes in trade and investment patterns. Other associated EC policies, especially in the areas of regional policy, competition, technology, environment, energy and technical standards will also affect a wide range of industrial sectors, and thus the prospects for industrialization in developing countries. The Expert Group Meeting will review the implications in terms of key industrial sectors: food, textiles and clothing, footwear, steel, chemicals, and electronics.

The present paper deals with one of these key sectors, electronics. It reviews trends in the world industry and examines the implications of the Single Market and European Community policy for the electronics sector in developing countries.

The paper was prepared by the Regional and Country Studies Branch of UNIDO, with Paul Hesp as UNIDO consultant.

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1. OVERVIEW AND GLOBAL TRENDS

a. General characteristics of the industry

The electronics industry occupies a very significant place in world industry, both because of its dynamic characteristics and because of the changes in modern manufacturing in general that have been brought about by progress in microelectronics technology. The industry is about to replace food processing as the number three among the manufacturing branches in terms of global MVA, having doubled its contribution to global MVA since 1975.[1] Although the electronics branch is not recession-proof, as 1991 has shown[2], it might be the largest industry of the world by the year 2000.[3] One branch, the computer industry, alone now employs over 3 million people, and annual sales were over US$ 307,000 million in 1990.[4] Electronics products such as computers and control systems contribute to all aspects of manufacturing activity, both in terms of actual production and all associated administrative tasks. Together with biotechnology and advanced man-made materials, the electronics industry is a leader on the innovation frontier.

World production is very heavily dominated by three countries/country groups: the USA, Japan, and the EC, accounting for 37 per cent, 25 per cent and 25 per cent, respectively, of world electronics production in 1990. While the USA had roughly the same share in world production and in the world market for electronics, Japan's share in production was much larger than its share in the world market (18 per cent); the EC's market share of 30 per cent was considerably higher than its share in production (see Table 1). The EC, in other words, has a negative trade balance with regard to electronics, and this balance has continued to deteriorate over the past decade.

Table 1. **ELECTRONICS INDUSTRY/GLOBAL DISTRIBUTION IN 1990**
(billions US$ and percentages)

	Production		Market		Balance (bn US$)
Total, all products					
USA	333	37%	334	37%	-1
Europe	230	25%	270	30%	-40
Japan	223	25%	161	18%	62
Rest world	122	13%	143	15%	-21
TOTAL	908	100%	908	100%	0
Active components					
USA	20	27%	22	29%	-2
Europe	11	15%	15	20%	-4
Japan	36	48%	26	35%	10
Rest world	8	10%	12	16%	-4
TOTAL	75	100%	75	100%	0
Consumer electronics					
USA	11	13%	23	26%	-12
Europe	16	18%	29	33%	-13
Japan	36	41%	16	18%	20
Rest world	25	28%	20	23%	5
TOTAL	88	100%	88	100	0

Source: Based on KEG 1991.

[1] UNIDO 1991c, p.7

[2] See for instance Standard 1992, p.21.

[3] Electronics 1/1991, p.51.

[4] Futures 1991, p.960.

The actual players on the world market are a number of large firms which are active all over the world from a home base in the industrialized countries. One hundred firms accounted for almost 80 per cent of world sales in 1990; the top 10 among these accounted for 40 per cent by themselves. Of the top 100, 43 are American, 31 are Japanese and 23 are European (most of these are from the EC); there are only three companies from developing countries, all of them from the Republic of Korea. Of the top 10, six are Japanese, with two US and two EC companies accounting for the remainder. Turnover per employee was highest in the Japanese firms, and lowest in the European firms; net profits and R&D expenditure as a percentage of turnover were also lowest in the European firms.[5]

Mainly with the objective of benefitting from low wages - the avoidance of trade barriers is another reason - there has been a widespread movement of electronics firms to production facilities in developing countries. By the mid-1980s, for example, more than one-third of all jobs in US semiconductor firms were to be found in offshore locations, and one-fifth of all employees of Japanese electronics firms were employed outside Japan.[6] Although these figures include employment in subsidiaries in developed countries, where establishing a market presence was the more important consideration, the great majority of these jobs were found in developing countries. By 1990, out of 770 overseas production facilities of Japanese electronics firms, over 500 were located in developing countries, largely in East and Southeast Asia.[7] European firms were less active overseas, yet by 1990 some 200,000 persons were employed in overseas subsidiaries of EC firms, constituting almost one-fifth of their workforce.[8]

In recent years, the overall demand for cheap labour has slowed down. This is a consequence of the increasing automation of basic operations and the growing complexity of other operations. Cheap labour is still wanted for so-called "back-end" activities such as assembly, testing and packaging. In other activities, it is the demand for skilled personnel that is increasing. "People who were on the production line are now doing things that used to be done by technicians. Technicians are doing things that engineers used to do".[9]

Even in a developed country such as the USA, electronics manufacturers are confronted with the problem of labour force entrants whose basic educational attainments are insufficient for the present requirements of the industry.[10] It is clear that developing countries wishing to attract subsidiaries of electronics firms can no longer rely on low wages alone in the future. Although the relocation of back-end activities would still provide new employment in countries with a cheap, unskilled labour force, there will be an increasing need for solid, widespread basic education, and for technical

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[5] Humbert 1992.

[6] UNIDO 1988, p.236.

[7] Humbert 1992, p.26.

[8] KEG 1991, p.9.

[9] Electronics 7/1991, p.48.

[10] Electronics Business 3/1991, p.36.

training in the field of electronics, if a country wants to make any progress in the electronics industry. This is particularly important for women, who tend to predominate in the unskilled labour category.

As indicated above, firms from developing countries play a very modest role at the global level. The most important countries with a domestic electronics industry, apart from the Republic of Korea, are Brazil, Singapore, Taiwan and India. Of these, the Republic of Korea is by far the most advanced. Much of the production in these countries is based on imported technologies and components, but countries such as Republic of Korea, Brazil and India are also involved, with varying degrees of success, in R&D and the creation of their own electronics industries.

The electronics industry is characterized by a very high rate of innovation, and new products and technologies continuously vie for market shares. Innovation requires very high levels of R&D expenditure - developing a new microprocessor may cost US$ 300 million or more - and highly qualified personnel. In all the major industrialized and developing producer countries, governments, aware of the strategic economic (and military) importance of the industry, therefore play a very strong supporting role in R&D. Banks also play a key role, by financing R&D. In Europe, however, banks have been reluctant to provide such financing, and in comparison to, in particular, Japan, costs are high.[11]

Continuous improvements in performance of electronic products which result from innovation, combined with heavy competition exert a strong downward pressure on prices. According to one source, computer performance is now doubling every year, while prices decrease by up to 30 per cent.[12] New products now appear in a nine-month cycle in the consumer electronics industry.[13] A company that enters the market for a new product too late will find it difficult to make sufficient profit on its outdated product to finance R&D for the next generation of products.

The immense R&D costs and the struggle for market shares is leading to an increasing number of mergers and to technical co-operation agreements between the major producers. Here again, the US and Japanese firms tend to be in stronger positions than those from Europe.[14] The end of the Cold War, with its partial disarmament of the leading industrial nations is also negatively affecting the electronics industry and is likely to lead to further reorganization.

The electronics sector has a strong relationship with services. Sales-related services and repair/maintenance, e.g., are of essential importance to ensure that the customer acquires the right package of products and gets maximum "mileage" from the often complex and expensive equipment during its technical life.

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[11] KEG 1991, p.15.

[12] Standard 1992, p.21.

[13] Business Week 6/1990, p.62.

[14] See inter alia Standard 1992, p.21.

Another aspect is the rapid increase in information services which are based on telecommunications and data processing equipment. Electronic data interchange (EDI) is a characteristic example. This is a method used by some large companies to order and invoice products electronically. Under this system, no paper changes hands. Instead, orders are made out on a computer screen and dispatched, using special codes, over the telephone. The supplier uses the system in reverse. While EDI requires a large amount of standardization in the procedures used by participants, its long-term advantages are greatly reduced paperwork, greater accuracy and lower costs. Developments of these concepts, including the integration of the design phase, form the basis of trends towards computer-integrated manufacturing (CIM). The impact of information systems on the competitiveness of banking, insurance and other financial services is also highly significant.

b. Sub-groups in the electronics industry

Against this general background, the individual sub-groups in the industry each follow a particular development path. The major sub-groups are:

- Components;
- Industrial electronics, which can be subdivided into:
- Telecommunications equipment;
- Computers/office equipment;
- Consumer electronics;
- Software.

Components

Components are the building blocks for the production of other electronic equipment. Some basic components have become of crucial importance for further progress in the industry. One basic building block is the memory chip, in which information can be stored. The amount of information that can be stored has risen very rapidly during the past few years. In the late 1980s, 1 Mbit memories (i.e. chips which could store one million "bits" of information) were a common product. These were soon followed by 16 Mbit memories, and at present, a new generation of 64 Mbit memories is being developed.[15]

Another basic component is the microprocessor, which can be programmed for a variety of functions and can execute a series of programmes. It incorporates the basic characteristics of a computer's central processing unit (CPU) on a single chip. The manufacture of sophisticated microprocessors, especially those used within the computer industry, is dominated by a few large firms. While the market life of microprocessors is quite long for other applications, the manufacture of personal computers has led to a considerable shortening of the period between the introduction of new models, because of the intense competition among manufacturers and the search for improved power and speed to allow the personal computer to undertake ever more demanding tasks. Since the microprocessor will be faster if it is smaller, because of the reduced length of the interconnections within it, the manufacturing process becomes more sophisticated and capital-intensive with each generation of chips. The search for new materials, the complex design and construction of microprocessors and the miniaturization trends all require very highly qualified personnel and financial resources. Research, development and mass

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[15] UNIDO 1988, p. 55; CEC 1991, pp.12-15.

production of the basic building blocks relies on extremely sophisticated machinery.

The "cutting edge" of the electronics industry is therefore the domain of a handful of large enterprises, predominantly in the USA and Japan. The world market shares (for all components) of these two countries were 45 per cent and 34 per cent, respectively, in 1989.[16] In general, Japanese firms dominate the DRAM market, while United States firms dominate the microprocessor market. Firms from the Republic of Korea have however made considerable gains and are now estimated to have 15 per cent of the world DRAM market.[17]

Industrial electronics

Industrial electronics include, apart from telecommunications equipment, computers and office equipment, other fields such as factory automation, medical and military electronics; the scope of the present paper does not allow a treatment of these other fields. There is a convergence between the telecommunications and computer industries, the digitalization of the former enabling data traffic; likewise, convergence between consumer electronics and industrial electronics is a possibility, with the introduction of the digital compact disc (CD).

Telecommunications equipment has witnessed a series of technological breakthroughs, and is diversifying away from the telephone to a range of text, image, data and voice communications products. As a consequence, network operators are faced with strong modernization pressures. The technology changes revolve around the shift to digital signalling, messages transferred through the communication systems being broken down into electronic "bits" of information. This allows the combination of various forms of communication, and the development of Integrated Services Digital Networks (ISDNs). In addition, copper cabling is being replaced by fibre-optic cables and wireless transmission, allowing a strong increase in the volume of telecommunications traffic.

Furthermore, the telecommunication industries in the developed countries is being deregulated. The disappearance of monopolies and the appearance of a variety of new operators on the market specializing in e.g. data transmission has resulted in additional demand for telecommunications investment. The consumer market is expanding as a consequence of the above mentioned combinations of communication modes that are now possible (such as the combination of a telephone with a fax machine), and the growing sophistication of mobile communications equipment. A rapid increase in demand for telecommunications equipment may also be witnessed in the more advanced developing countries. Generally speaking, the lack of reliable, widespread telecommunications services in developing countries is a major constraint to industrial development and to overall economic progress. However it should also be noted that progress in telecommunications technology has been such that it offers significant competitive advantages for latecomers in its adoption.[18]

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[16] CEC 1991.

[17] ECE 1992, pp. 143,146.

[18] Antonelli 1991, p.11.

In the computer industry, the characteristics of the basic products being sold and their market shares are changing rapidly. There are now three major product segments: small (personal computers - PCs), medium (powerful workstations and minis) and large systems (mainframes). In 1987, these segments accounted for, respectively, 35 per cent, 41 per cent and 24 per cent of the world market, with a trend away from the large systems.[19] Technological progress allows many operations that previously required a large machine to be carried out by much smaller and cheaper equipment. The trend towards decentralization of many large organizations has been an important stimulus for the growing demand for small yet powerful computers; at the same time, the possibility to create networks of PCs helps to make further decentralization of activities possible.

Another important development in the computer market is the increasing trend towards "open systems" where interconnection is possible. In the past, producers of computers and of software (see below) all used their own systems, which were not mutually compatible. The segmentation of the market by such "proprietary systems" eventually became an obstacle to the widespread use of computers, and therefore to the growth of the industry. Standardization, especially of the smaller, mass-produced computers, is now making rapid progress. This is stimulated by developed country governments which are important purchasers of computers and have an interest in setting generally applicable standards. Software producers also have a particular interest in a stable hardware and systems software environment in which they can produce products with long marketing life, since software products are characterised by major development costs, with actual production costs being negligible. This development is a sign that certain parts of the computer industry, like earlier growth industries, are reaching maturity in the product life cycle.

Consumer electronics

The major categories of consumer electronics include video equipment (television, etc.), audio equipment (radios, etc.) and accessories. In this sub-sector, technological innovation has been very rapid during the 1980s. At present, the main new innovation about to be launched on the market is High Definition Television (HDTV), with its greatly improved screen image. The development of a standard for HDTV has been a particularly controversial process, since it is seen as an important strategic issue for the consumer electronics industry in Europe in particular.[20]

Although stimulated by the development of new types of media (such as satellite broadcasting) and the boom in television stations following deregulation in a number of developed countries, demand at present only grows slowly, as a consequence of stagnation or recession in the industrialized countries, which, in the electronics industry, has particularly affected the major types of consumer electronics. Competition is fierce, and the stakes are not only economic but also cultural, as audiovisual equipment has become an important cultural and educational vehicle.[21]

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[19] Futures 11/1991, p.962.

[20] UNIDO 1991e, pp.29-30.

[21] Electronics 1/1991, pp.50-51; CEC 1991, pp.12-38, 39.

Software[22]

Software is the set of instructions needed to operate anything that is programmable - computers, but also machine tools, communications equipment, etc. Software can be designed by computer manufacturers, independent software producers or by the users themselves. Although the present paper focuses on hardware ("machines"), some attention must be paid to software, as progress in hardware must be matched by progress in software. The software industry is therefore strongly influenced by the rapid technological change in the electronics industry and fierce competition among hardware producers.

As much of the software is developed within companies or institutions for their own use, it is hard to estimate the value of software production or the size of the markets. One recent estimate of the world software market gave a value for packaged software of US$ 22,300 million in 1989, a four-fold increase over 1984. The USA is definitely the largest producer, with a world market share of perhaps 70 per cent. The main markets are found in the developed economies.

The software industry is both skill and labour-intensive. There is a tendency towards increasing the use of equipment in the design of software, shortening development time to keep pace with developments in hardware. In general, although many large firms exist, and although the human capital requirements for the more advanced software are very high, the software industry remains open to newcomers. Because of constant changes in technology, it provides many niches for which distinctive products can be developed, and these may not require unique talents.

To maintain or improve competitiveness and efficiency in all economic sectors, and to provide efficient government services, local software expertise is becoming increasingly important in developing countries. The mastery of such skills is essential if a country is to control the direction of its informatics development, for reliance on imported software means relying on imported ways of using hardware - and these may not lead to the result required in the local context. Informatics also constitute one major means by which developing countries can increase their international competitiveness - in many industries, cheap unskilled labour-intensive activities are no longer competitive with automated factories in the industrialized countries. Those countries who have the human resources for software production can explore foreign software markets - India is the best known example in this respect.

Expected developments in the electronics industry could include a continuing trends towards obsolescence of hardware and its replacement by more powerful generations. This in turn will further stimulate the software industry to take advantage of the increased possibilities of the hardware. Continuing increases in the complexity and functionality of package software will also take place. As the possibilities of interconnection and alternative applications continue to expand there will also be an growing demand for integration services and systems engineering, especially given the broadening scope of telecommunications and its convergence with information industries. This in turn means that of total activity the components share by vale may decrease. As against this there will be perhaps diversion of government R&D expenditures towards civilian purposes, together with an increase in skill

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[22]Based on Gahan 1990.

availability in those countries in which military spending has been an important share of economic activity.

2. THE ELECTRONICS INDUSTRY IN THE EC

a. Characteristics

Present structure

The electronics industry (including software production and information services) accounted for 5 per cent of the GDP of the EC in 1989; by the year 2000, this share is expected to have grown to 10 per cent. Excluding software and information services, the industry accounted for 8 per cent of the Community's industrial production in that year. As elsewhere in developed countries, the importance of the industry is much greater than its mere production shares: electronics is increasingly a key factor in the competitiveness of other economic activities.[23] Employment in the sub-groups of the industry (components, industrial and consumer electronics) is around 860 thousand, with a clear tendency towards decrease.

Although the EC's electronics industry only ranks third in global production, it has grown vigorously during the 1980s. Table 4 shows that between 1981 and 1990, total production increased from 47,600 million ECU to 103,900 million ECU, an increase of 118 per cent (Table 2).

Table 2. EUROPE'S EXTERNAL TRADE BALANCE, 1974 – 1996 (billions US$)

	1979	1984	1990	1996
Components				
Active	-0.3	-2.6	-4.2	-7.3
Passive*	-	-0.3	-1.8	-3.3
Industrial electronics				
Telecommunications	1.7	1.4	0.6	0.9
Communications	1.4	1.7	3.4	3.7
Computers	-2.3	-6.5	-20.3	-26.5
Software	n.a.	-0.7	-2.1	-2.7
Office automation	-0.3	-1.1	-2.4	-2.9
Factory automation	n.a.	-0.9	-2.7	-3.8
Measuring instruments	0.3	0.4	0.9	1
Medical	0.3	0.6	1.1	1.5
Consumer electronics	-2.4	-4.1	-12.6	-18.1
TOTAL	-1.5	-12.1	-40.1	-57.5

n.a.: not available.

* Passive components do not include parts for consumer electronics.

Source: Based on KEG 1991.

[23] CEC 1991, 12-2,3.

Computers and telecommunications equipment have always been the most important products, but while telecommunications equipment was the number one product at the beginning of the 1980s, it was soon overtaken by computers and office equipment, the fastest growing category of products. By 1990, its share in total electronics output was 47 per cent; computers and telecommunications equipment together accounted for 72 per cent of total output in that year. Relatively speaking, telecommunications was a slow grower, with a growth of 58 per cent over the 1980s. Comparably low growth rates for the decade were found in consumer electronics (50 per cent) and in the relatively small passive components industry (54 per cent). The low growth rate in consumer electronics may partly be due to decreasing product prices rather than to lagging demand for EC-made products.

In spite of the industry's growth, the EC's electronics trade balance has deteriorated continuously over the past decade. In 1990, the EC's trade deficit amounted to US$ 40,000 million, as compared to a deficit of US$ 1,500 million in 1979 and of US$ 12,100 million in 1984 (see Table 3). Computers and consumer electronics accounted for 85 per cent of the EC's trade deficit in 1990. Only in the case of (tele)communications equipment and some minor categories of products did the EC have a slight trade surplus. The negative balance is expected to increase to US$ 57,500 million in 1996.

Table 3. TREND IN EC PRODUCTION IN CURRENT PRICES, 1981–1990 (million ECU)

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990**
Electronic components	7,777	8,576	9,762	12,368	13,228	13,615	13,772	14,406	15,413	15,969
Active components	3,282	3,712	4,385	5,858	5,973	6,218	6.289	6,598	7,344	7,601
Passive componenets	1,568	1,691	1,787	2,060	2,121	2,187	2,193	2,261	2.349	2.419
Electro-mechanical components	2,927	3,173	3,590	4,450	5,134	5.210	5,290	5,547	5,720	5,949
Computers and office equipment*	14,746	19,580	23,961	29,365	35,388	35,326	36,053	41,553	45.663	49,090
Telecommunications equipment	16,379	17,593	18,543	20,601	22,390	22,226	22,584	22,939	24,328	25,708
Consumer electronics	8,671	9,850	8,064	7,803	8,895	12,111	12,526	12,906	12.243	13,020
TOTAL	47,573	55,599	60,330	70,142	79,901	83,278	84,935	91,804	97,647	103,877

* Excluding Greece, Portugal and Spain.

** Estimates.

Source: CEC 1991.

The industry is largely concentrated in the four largest EC economies: France, the Federal Republic of Germany (FRG), the United Kingdom (UK) and Italy. These accounted for 89 per cent of production and 88 per cent of R&D in 1989, a considerably higher ratio than their 72 per cent share in the population of the Community (CEC 1991, 12-2).

The strongest developing country presence is in consumer electronics, although most of Europe's imports from these countries come from subsidiaries of Japanese and US firms. The Republic of Korea and Hong Kong together provided over 50 per cent of the imports from developing countries in the late 1980s.[24]

The 15 most important European suppliers (not all of them located in EC countries) are shown in Table 4. The two largest companies are Siemens (FRG) and Philips (Netherlands); these were also the only two European companies among the world top 10 in 1990. These two firms and the French firms GCE-Alcatel and Thomson accounted for 26 per cent of all electronics sales (EC and non-EC companies combined) in the EC in 1989. Seven out of the 10 top suppliers of electronics in the EC market are EC companies, and EC firms have a particularly strong position in telecommunications equipment.

Table 4. THE TOP 15 EUROPEAN ELECTRONICS SUPPLIERS, 1989

	Total sales 1989 (million ECU)	Total employment 1989 (tousands)	World electronics sales 1989 (million ECU)	EC electronics sales 1989 (million ECU)
Siemens	31,770	353	16,830	1,050
Philips	25,000	310	14,760	6,960
CGE Alcatel	24,500	204	12,000	8,000
Thomson	10,930	104	10,040	5,400
Olivetti	6,320	58	5,880	3,570
Bull	5,820	46	5,820	3,190
GEC	10,660	145	4,790	3,570
Ericsson	4,430	65	3,700	1,480
Bosch*	13,380	165	3,360	2,530
Plessey*	2,470	26	2,960	1,250
Nixdorf	2,835	31	2,835	2,420
STC	4,480	34	2,830	2,020
Nokia*	4,420	45	2,620	1,410
STET*	10,600	n.a.	2,040	1,790
Daimler-AEG	36,900	339	1,560	1,190

* Total sales 1988.
Source: CEC 1991.

[24] ECE 1992, p. 160.

b. Key aspects of the Community's unification

The Single European Market

In 1993, there will be a Single European Market among Community partners. The consequences of the disappearance of the internal barriers include possibilities for increased economies of scale. According to one estimate, these factors might result in a reduction of the Community's overall imports by some 10 per cent; this could however be neutralized by a greater demand for non-EC products arising from an overall increase in Community GDP.[25] Similarly, it is not clear whether the replacement of national restrictions on imports by EC restrictions will have a positive or negative overall effect on non-EC producers. The effects will differ at the level of individual industries. The unification of the Community market and the application of community-wide standards are estimated to lead to potential scale-economy gains of around 1,000 million ECU in the case of telecommunications equipment. Community-wide procurement based on EC standards - recently estimated at US$ 20,000 million annually - could possibly lead to additional gains for Community producers that are a multiple of this figure. On the other hand, stronger competition from US and Japanese suppliers in the unified market is expected, where at present government procurement of telecommunications equipment alone is estimated to amount to US$ 20,000 million annually.[26]

Concentration, inter-firm co-operation and foreign investment trends

As in other high-technology industries, there have been strong takeover pressures in the European electronics industries. The high investments in research make it very difficult to achieve sufficient economies of scale in separate national markets. The prospect of the Single European Market has led to a large number of mergers and acquisitions across the borders. Examples include CGE-GEC, Siemens-GTE and SGS-Thomson. This process does not only involve EC companies. For instance, the US firm ATT and Fujitsu from Japan also have stakes in EC enterprises. EC firms have also taken over non-European firms: The French firm Thomson now owns the consumer electronics division of the US firm General Electric. Mergers and acquisitions reached a level of ECU 3,869 million in 1989; the electronics industry was the fifth largest takeover target in that year.[27] The process will no doubt continue after market unification: for the period September 1990 to March 1992, in a total of 203 mergers and acquisitions involving EC companies, no fewer than 72 were in the electronics sector.[28]

The tendency towards concentration is illustrated, among others, by the fact that in 1983, five companies accounted for 74 per cent of the European semiconductor industry; by 1988, their share had risen to 83 per cent. Interestingly, the main "victims" would appear to be medium-sized producers: the share of small producers, while modest, had also increased. This would indicate an increase in market niches for specialized products, perhaps based

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[25] Winters 1991, p.37.

[26] See CEC 1988, p.78; CEC 1991, 12-27; Electronics Business 3/1991, p.81.

[27] CEC 1991, 12-5, 44,71.

[28] UNIDO, based on Financial Times data.

on existing technologies which do not require major investments.[29] Such niche markets, on the other hand, tend to be volatile, and a certain "robustness" may be required if firms are to survive their ups and downs. This would exclude very small firms.

There are arguments in favour of and against investment by non-EC firms. Such investment would help to diffuse new technologies and production methods; on the other hand, it diminishes market shares of EC firms, and may result in technological dependency, turning the Community's industry into a collection of "branch plants". As it is, most EC countries have liberal laws with regard to foreign investment. Much of the foreign investment in individual countries is from inside the Community, but in the electronics industry the major overseas producers, including the Republic of Korea, are making significant investments in the EC. Less advanced members such as Portugal have attracted much investment in the labour-intensive segments of electronics manufacturing. Ireland has been successful in attracting foreign investment in this field, because of a combination of low wage rates, low corporate profits tax and also a deliberate targeting of this sector. A country like the Netherlands, which has an important electronics industry of its own, is very open to foreign investment, but its anti-takeover laws are very strict. France has long been relatively hostile to foreign investment; this attitude has changed in recent years.

In general, it is to be expected that the trend will be to further liberalization as EC policy with regard to this issue develops. The Community has however proposed a system of prior and rapid control of mergers that are likely to substantially reduce competition within the EC, and the European Commission's present powers with regard to operations that are not in the Community's interest are to be strengthened[30]

Apart from the mergers and acquisitions, there is a trend among firms to join forces while retaining their independence. In 1990, an agreement was signed between IBM, the world's largest manufacturer of chips, and Siemens, one of the EC's top producers of components, to develop jointly the next generation of 64Mbit chips, with regular production to start in the mid-1990s. The huge development costs - estimated at ECU 450 million - were a major reason for this agreement. Another development is original equipment manufacture (OEM), in which firms such as Siemens and Bull produce computer equipment for Japanese companies to market under their own name.[31]

Co-operation is being encouraged by a new EC legal instrument, the European Economic Interest Grouping (EEIG). Aiming specifically at small and medium-scale enterprises (SMEs) involved in similar economic activities, it removes a large number of legal obstacles to cross-border co-operation. Registration with the local or national authority is the only requirement. The EEIG facilitates, among others, cross-border R&D; joint bidding for, and execution of, public works and supply contracts; pooled transport and dis-

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[29] UNIDO 1989b, p.161.

[30] CEC 1991, p.39f; CEC 1988, pp.138-139.

[31] CEC 1991, 12-15,31.

tribution; and joint ventures with non-EC companies in order to open new markets.[32]

Trade policy

The Community's trade policy is to provide stimuli for the electronics industry by focusing on the following key issues:[33]

- Openness in international trade relations and fair trading practices;
- Improved access to the markets of the other major producers: the USA, Japan and the Republic of Korea;
- Increased international co-operation in scientific, technological, industrial and general economic areas;
- The creation of a truly European market through new agreements with the EFTA and East European countries;
- Assistance to restructuring in Eastern Europe.

With regard to the first two issues, the outcome of the GATT negotiations is considered to be of great importance, especially in the fields of semiconductors and consumer electronics where trade barriers place the Community's industries at a disadvantage, especially in Japan. The EC on its part is willing to ease access of non-EC consumer electronics to the markets of its member countries. The possible extension of the US-Japanese Semiconductor Agreement, which expired in late 1991, is another matter of concern, as it could have negative consequences for the Community's electronics industry as a whole.[34]

The Community is particularly alert to dumping, which has been used by overseas competitors to gain market access. Anti-dumping measures procedures are seen as a means of last resort, but the Community has shown on numerous occasions in recent years that it will not hesitate to initiate anti-dumping procedures if EC producers of electronics are perceived to suffer as a consequence of unfair trading practices.

Since 1985, semiconductors, photocopiers, printers, videorecorders and TV-sets from overseas sources have been the subject of anti-dumping measures. In the case of semi-conductors (DRAMs), an agreement was reached with Japanese producers in 1990 after the imposition of a stiff provisional anti-dumping duty of 60 per cent, the normal EC tariff being 14 per cent. Under the agreement, minimum prices are reviewed every three months during a maximum period of five years. Developments with regard to the US-Japanese Semiconductor Agreement will also be taken into account.[35]

Certain electronics imports from developing countries have benefitted from tariff reductions. The reductions have so far been the responsibility of individual member countries, within a framework set by the EC. The Asian NICs, Mexico and Brazil, as well as Turkey and the North African countries (in

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[32] International Management 5/1990, p.47f.

[33] KEG 1991, p.12.

[34] KEG 1991, p.26.

[35] KEG 1991, p.27; CEC 1991, 12-13,14.

the case of France only) have been the main beneficiaries.[36] It may be assumed that these tariff reductions will be replaced by an EC-wide system in the near future.

Community R&D

To defend and expand its shares in the world electronics industry, the EC is supporting several large research projects in which the Community's major producers are collectively involved since the late 1980s.[37]These include:

ESPRIT II: This 1987-1992 programme groups over 400 projects in the field of information technologies. EC contribution is 1,600 million ECU. Projects include the creation of a multiprocessor computer.

RACE: This programme, which is to end in 1992, involves 88 programmes in the field of fibre-optics based data communications; the objective is to lay the technological foundations of Integrated Broadband Commmunication, which should function by 1995. The EC contribution is 550 million ECU.

A shortcoming of these activities, as the European Commission has pointed out, is that there is in most cases too little co-operative follow-up among firms at the product development stage. The Commission considers this to be of crucial importance if the EC is to retain the initiative with, e.g., HDTV. It suggests that future programmes encompass all stages from basic research to marketable products.[38] (KEG 1991, 17).

According to the Commission, the 1990-1994 EC policy framework for R&D should also be better focused, with a smaller number of less exacting tasks, and more co-operation with future users; more attention should be paid to international co-operation and the development of human resources (research personnel, engineers). With regard to the latter, an expansion of the relevant existing human resource development programmes is to be expected. At present, the FRG and France, which have a combined population the size of Japan, only train 41,000 engineers yearly, just over half of the Japanese number. Cooperation between universities and enterprises is to be strengthened. Future research would focus on:

- Software development;
- Computer-integrated manufacturing;
- Micro-electronics;
- Peripherals;
- Telecommunications;
- Supercomputers.

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[36]UNIDO 1988, pp.238-240.

[37]See inter alia Business Week 6/1990, p.63.

[38]KEG 1991, p.17.

The second Framework Programme 1990-1994 devotes approximately 40 per cent of the ECU 5,700 million budget to information and communications technologies.[39]

The Communit's International Scientific Cooperation Programme could be of interest to developing country producers. it is focused on pre-competitive research requiring further development into marketable products. Because of this focus it would only be of interest to countries with an established industry. Activities include post-doctoral fellowships. joint research, and workshops. The programme is carried out in the framwork of wider bilateral agreements.

EC standards

EUREKA: Although not part of the Community's R&D programme as such, both the Copmmission and the member states also participate in the programme. This also includes the EFTA-countries and Turkey. The programme involves 295 projects in nine advanced technology areas, with a total cost of US$ 7,500 million. A major component of EUREKA is JESSI (Joint European Submicron Silicon Initiative), an eight-year programme with an estimated total cost of US$ 4,000 million. The development of HDTV, costing US$ 800 million, also comes under this programme.

European manufacturers have identified the vast and growing number of different technical regulations and standards (the former are binding, the latter voluntary) in the various Community countries as an important barrier to trade. Different legislation leads to duplication of R&D costs, loss of efficiency as production runs have to be adapted, increased distribution costs, etc. It is a major obstacle to the development of the manufacturing sector, and increases public sector costs as imported goods must be tested and certified.

The Community's policy instruments for removing this barrier include:
- Mutual recognition of national regulations;
- Harmonization of such regulations;
- Strengthening of the European standardization bodies CEN and Cenelec (of which EFTA countries are also members);
- Obligatory mutual information;
- Freezing of new national regulations in the interest of Community action.

In the case of the electronics industry, institutions like the European Telecommunications Standards Institute play an important role. Terminal equipment is to be certified on a Europe-wide scale. Standardization could in certain cases lower the cost of software used in the telecommunications industry by 80 per cent.[40]

The introductio. of a Community Patent in 1993 would have similar advantages. It should be pointed out that EC-wide standards and patents are not only to the advantage of entrepreneurs in member countries: they should

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[39]CEC 1990, p. 11.

[40]CEC 1988, pp.49-50, 78.

also stimulate activities of overseas firms - provided that these can cope with the requirements.[41]

Regional issues

As part of a general principle of seeking equal distribution of the benefits of European integration, there has been and will continue to be an emphasis in EC policy on accelerating the development of the more disadvantaged areas of the Community. These include those on the geographical fringes of the Community such as Portugal Greece and Ireland, although economically depressed regions within individual countries (such as the United Kingdom) will also qualify for assistance. The in some cases large expenditures in re-training schemes may improve skill levels in areas related to the electronics industries. Heavy infrastructure expenditures will improve the possibilities of foreign investment. Support for the creation and running of small businesses will encourage new software and microelectronics application firms.

c. The opening of Eastern Europe

Eastern Europe has so far not played an important role in world electronics. Although some of the countries have a relatively large industry, notably the former German Democratic Republic (GDR), the Baltic states and the Commonwealth of Independent States (CIS), no Eastern European electronics firms are found among the world top 100, productivity is low and technologies are not the most advanced, with the exception of some military and aerospace-related applications. Only 1 per cent of EC electronics imports in 1988 came from Eastern Europe[42], and it can safely be assumed that other developed countries imported even less from Eastern Europe. Electronics-related services are underdeveloped. Poland and Romania have only very small electronics industries. The Bulgarian industry is very small as well, but could be of some future importance: within the CMEA division of labour, the country was assigned an important role as a producer of computers. Some countries, in particular the CIS and Hungary, have developed a considerable expertise in software development.

As Eastern Europe has in the past imported very little from the leading producer countries, the East European countries are also seriously underequipped with regard to computers and telecommunications, and consumer electronics still play a modest role in comparison with the rest of Europe. An example: Czechoslovakia has the highest density of telephones in Eastern Europe, 239 per 1000 inhabitants. This is still lower than the second-lowest figure for the EC (Ireland: 265), and only about one-third of the figure for EC countries with a high living standard such as the Netherlands and the FRG.[43]

The opening-up of Eastern Europe will lead to a vast increase in demand for industrial electronics, if the economies of the countries in question are to become internationally competitive. One estimate suggests that the modernization of the telecommunications networks alone will require an

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[41] See, for instance, Electronics 11/1991, pp.48-52.

[42] CEC 1991, 12-4.

[43] CEC 1991, 80.

investment of US$ 350,000 million.[44] It will probably take considerable time for living standards to catch up, and therefore demand for consumer electronics will not grow as quickly, although there are differences among countries, with e.g. Hungarian living standards a multiple of those now prevailing in large parts of the CIS.

As the domestic industries are incapable of coping with the increase in demand and of providing the higher technology standards required, modernization and expansion of industrial electronics will depend on imports and co-operation with firms from the developed market economies. An eventual privatization of telecommunications networks would also offer major opportunities for such firms.

Proximity to East European markets and traditional trading ties provide some of the EC countries (the FRG in particular) with a certain advantage in exploring both markets and investment opportunities. So far, electronics exports to Eastern Europe have been very modest, accounting for no more than 3 per cent of total EC exports in 1988. This very low figure obscures large differences among individual products: the former USSR, e.g., was the largest buyer of EC-made components in 1988, accounting for 43 per cent of total exports - which were modest - in 1988. Recently, Alcatel and Siemens have acquired a strong foothold in, among others, the telecommunications industries in Hungary and Czechoslovakia through a number of joint ventures.[45]

Apart from establishing a presence in likely future growth markets, one other major reason for locating electronics manufacturing activities in Eastern Europe could be the availability of comparatively cheap but skilled and even highly qualified labour. Figures were not available at the time of writing, but in the former GDR alone - admittedly one of the more advanced countries - some 200,000 scientists (all specializations) were available in 1990.[46] Among these, a fairly large number of electronics experts would be found. While skills and knowledge are often not up to the standards required at the "cutting edge" of the industry, re-training could in many cases be relatively easy, especially for the electronics industry segments where standardization is taking place. Software houses from developed market economies are already subcontracting production in, among others, Hungary.

A less tangible factor, which is nonetheless important, is culture. "To be global requires understanding cultural issues". [47] The cultural proximity between Eastern an Western Europe ensures that less time and energy must be devoted to this issue. It remains to be seen, of course, how rapidly the "bureaucratic culture" which was a pervasive influence in East European societies for decades, will disappear under the influence of liberalization and privatization. At least initially, this factor may cause problems and delays.

European firms may be well placed for a major role in Eastern Europe; the "Panorama of EC Industry 1991-1992", however, specifically singles out

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[44] International Management 10/1990, p.63.

[45] CEC 1991, 12-16, 27.

[46] Business Week 6/1990, p.68.

[47] Electronics 7/1991.

"the key industries of information and communications technologies" as an area where EC companies must once again expect heavy competition from US and Japanese firms which are, moreover, more advanced in some fields. In 1991, e.g., East European demand for semiconductor components was calculated at some US$ 1,000. As indicated above, this is an area where the EC is relatively weak, and US firms are making determined efforts to becoming a dominant force in this particular market. Firms from the Republic of Korea are also active in the region: Samsung and Goldstar are establishing colour-TV plants in Hungary and in the CIS - the latter potentially a vast market. The European Commission has therefore suggested a priority action programme to ensure a stronger position of EC firms in the East European markets.[48]

3. THE ELECTRONICS INDUSTRY IN THE DEVELOPING COUNTRIES

a. Overview: the main producers

The major producers of electronics in the developing countries are found, as Table 5 indicates, in the countries on the Asian side of the Pacific Rim. Unfortunately, figures on the more advanced products which could be used for comparative purposes were very scarce at the time of writing. There were virtually no recent country-level figures for Hong Kong and Taiwan Province, both significant producers. The data in Table 5, however, carry an important message: they show that even the less sophisticated goods are only produced in significant quantities in a handful of developing countries, highly concentrated in one region.

Table 5. MAJOR DEVELOPING COUNTRIES PRODUCERS OF SELECTED ELECTRONICS PRODUCTS, 1988 (thousand units)

	Tape recorders	TV-sets	Radios	Electronic tubes	Telephones
China, People's Rep.	25,404	25,051	15,489*	...	7,216
Republic of Korea	19,876	14,820	1,414	36,701	6,956
Singapore	14,006**	2,807	19,618	...	...
Malaysia	...	1,221	21,070	...	...
Brazil	...	2,722	7,632	...	1,247

* Portables only.
** Incl. combined tape recorders/radios.
Source: UNIDO 1991.

With regard to the more sophisticated electronics, there is enough evidence from other sources to identify the Republic of Korea as by far the

[48] CEC 1991, 44, 93-94; Electronics 1/1991, p.37.

most important producer. As indicated above, it is the only developing country represented among the world's top 100 firms. The Republic of Korea moreover is the only significant exporter of semiconductors and telecommunications equipment among developing countries. In 1987, overseas sales of telecommunications equipment amounted to US$ 398 million, and the country had become one of the world's top 10 exporters. Total 1988 sales of semiconductors amounted to US$ 1,340 million.[49]

Returning to Table 5, the major role played by the People's Republic of China (PRC) is immediately evident. The PRC is a somewhat special case, as most of the production is intended for the vast domestic market, whereas the other countries on the Pacific Rim are heavily export-oriented. The PRC was the largest producer of TV sets, telephones and tape-recorders among the developing countries. With the exception of the export processing zones, the producers do not use very sophisticated technologies.

The largest producers of radios were Singapore and Malaysia. The few figures that were available suggest a similar structure of the electronics industry, and in both countries, subsidiaries of transnationals play a very prominent role. But Singapore, like the Republic of Korea and Taiwan Province, is no longer a location for low-wage assembly operations: it is increasingly becoming the location of state-of-the-art production activities, for which a highly trained labour force is now available.

Outside the Pacific Rim countries, Brazil is the only developing country that plays a significant role in the world electronics industry. The country's production has so far been primarily for the domestic market, as part of an import-substitution drive. This policy is now being abandoned, as a part of broader pressures to open up the economy.

Some of the developing countries, which are not represented in the table should be mentioned. Mexico has attracted a considerable amount of investment from industrialized countries during the 1980s. This was primarily US investment in assembly operations, attracted by cheap labour, proximity to US markets and a variety of incentives. By contrast, India has been very strongly oriented to production for the local market, like Brazil, with an even heavier reliance on domestic R&D and production capacity. The consumer electronics industry in Turkey has grown very rapidly in recent years, admittedly from a very low basis. Turkey is potentially an attractive location for EC producers, because of its proximity, low wages, and existing association links with the Community.

A brief description of the electronics industry in some of the major producer countries now follows.

b. Developments in selected producer countries

The Republic of Korea

In the Republic of Korea, the Ministry of Science and Technology has been very heavily involved in the promotion of R&D, the upgrading of human resources for the electronics industry (including overseas training and the diffusion of new technologies, special efforts being made to increase the technological level in the smaller enterprises. Government purchasing of,

[49] UNIDO 1989b, pp.160, 179.

among others, telecommunications equipment, also provides strong stimuli to the industry. The rapid expansion of Korean industry is thus backed up by the creation, with domestic products, of an up-to-date communications network.

Initially, manufacturing was based on licenses from foreign sources. But the country soon initiated local R&D to complement licensing, and improve indigenous capabilities. In the late 1980s, the government established a number of research co-operatives with the large electronics producers (see Table 6). During 1986-1990, these received a government financial support amounting to US$ 226 million. The main motive behind this initiative is the realization that the Republic of Korea will have to develop its own semiconductor technology in order to remain competitive. The high cost necessitated co-operation between the major partners (which all have large R&D departments).

Table 6. THE REPUBLIC OF KOREA'S JOINT SEMICONDUCTOR DEVELOPMENT PROJECTS, 1986 - 1990 (millions of US$)

Project name	Time period	Participants[a/]	Investments[b/]
Sub-micron Technology	Oct.1986 - Mar.1989	ETRI, SST, GSS, HEI	109.8
ETS Standard Cell ICs	Jan.1987 - Dec.1989	DTI, GS	4.2
300V Power MOS FET	Jan.1987 - Dec.1988	KEC, DTI	4.1
CDP IC	Jan.1987 - Dec.1988	GS. DTI	4.9
GaAs Semiconductor Materials	Jan.1987 - June 1989	GSC, SCC	6.9
High Lead-Type Leadframe	Jan.1987 - Dec.1989	Pungsan, Anam	47.0
VLSI Level EMC	Oct.1986 - Dec.1988	Dongyan Chemical, Anam	1.8
Automotive ICs	July1987 - June 1989	DEP, DEC, DTI	4.9
GaAs Photo Cell	Oct.1986 - Sept.1989	KEC, GS	3.8
Thin-film Transistor	July1987 - June 1989	GS, DEP	4.9
Digital Video IC	Oct.1987 - Sept.1989	GS, DTI	5.0
High-power Transistors	Jan.1988 - Dec.1990	KEC, HEI, SST	2.0
32-bit PC ICs	Jan.1988 - Dec.1990	DTI, HEI, KEC, SST	5.0
CCD Camera Manufacturg.	Jan.1988 - June 1990	SED, SST	4.5
CCD Image Sensor	Jan.1988 - Dec.1990	SED, SST	5.0
DAT IC	Jan.1988 - Dec.1989	SED, SST	5.6
Power Transistor Package	Jan.1988 - Dec.1988	Samsung Aerospace, SST	3.9
GaAs Epitaxial Wafer	Jan.1988 - Dec.1989	GSC, GS	3.0
		TOTAL	226.3

[a/] Key: DEP = Daewo Electronic Parts
DTI = Daewoo Telecommunications
ETRI = Electronics Technology Research Institute
GS = Goldstar Company
GSC = Goldstar Cable
GSS = Goldstar Semiconductor
GST = Goldstar Telecommunications
HEI = Hyndai Electronics Industry
KEC = Korea Electronics Company
SEC = Samsung Electroninc
SED = Samsung Electron Device
SSC = Samsung Corning Company
SST = Samsung Semiconductor and Telecommunications

[b/] Converted at a constant rate of US$ 1 - 800 won.

Source: UNIDO 1989.

Apart from this co-operative programme, the major producer firms also carry out independent R&D, and in order to ensure access to the latest developments, the four largest enterprises have set up R&D subsidiaries in the USA.[50]

The Republic of Korea has been successful in the semiconductor area, with Korean memories now internationally competitive. This, however, has gone at the cost of progress in such areas as application-specific integrated circuits (ASICs): simultaneous progress in all essential fields is only possible for the industrial giants Japan and the USA.[51]

As the Republic of Korea's domestic market is limited, the country's industry is heavily export-oriented; at the same time, the domestic market is protected by strong import barriers. Originally, firms relied on exports based on OEM, whereby a firm in the Republic of Korea would contract the production of specific products for a Japanese or US firm. Since then, firms are making an impact on the world market with their own products, and the experience of the Republic of Korea shows that, if the circumstances are right, an open economy is not a precondition to becoming internationally competitive.

Korea's electronics industries are increasingly relocating operations to other Asian developing countries - such as the Philippines, Thailand and Malaysia - in response to increasing labour costs at home, and trade barriers in the industrialized countries.[52]

The People's Republic of China[53]

In the past, technological progress in China's electronics industry was largely confined to the area of defence-related products. The 1987 R&D programme, however, has a much broader approach, and information and automation technologies are now integrated into the country's overall economic and scientific development programmes. Decentralization and reorganization have in recent years improved the industry's structure and stimulated R&D and its practical applications as well as training.

A more liberal investment climate (the government has, among others, provided tax incentives and EPZ-type facilities such as the Shenzhen Special Economic Zone) has resulted in the establishment of dozens of joint ventures with leading firms from the USA, Japan and Europe. These joint ventures are partly attracted by the huge Chinese market for relatively unsophisticated products, partly by the country's abundant cheap labour. But these joint ventures also help the PRC to upgrade its technologies, and some quite advanced products are now manufactured under joint-venture arrangements. The use of such products is encouraged by, among others, a large telecommunications modernization programme requiring investments of approximately US$ 2,900 million by 1995.[54]

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[50] UNIDO 1989a, p.27.

[51] Microelectronics Monitor 7/1991, p.39.

[52] Electronics Business 11/1991, p.36.

[53] Based on UNIDO 1991a.

[54] UNIDO 1989b, p.180.

As shown in Table 5, the PRC has so far been mainly a producer of relatively simple consumer electronics. For the better quality products, the country has so far relied on imported components. Micro- and mini-computers are a relatively recent and rapidly growing industry. Although progress has been made in the design and manufacture of components, these are also largely based on imports at the moment. Unique hardware and software have been developed to allow the handling of Chinese characters by information processing equipment.

While the industry remains focused on the domestic markets, exports of electronic products (largely produced by joint ventures) have risen rapidly during the 1980s, from US$ 203 million in 1980 to US$ 2,043 million in 1987. Consumer electronics accounted for some 60 per cent of exports in 1987, and the trend is towards a larger share of these products. From the increasing share of industrialized countries (in particular the USA) in total exports one may deduce that the quality of Chinese exports is improving.

Singapore

Singapore has made strong efforts to upgrade its labour force, partly through the medium of training courses set up in co-operation with transnational corporations. Educational levels are comparable with those in developed countries. Even so, the industry is suffering from a shortage of specialized personnel.

Another important government initiative was the establishment of a Science Park in 1979, and many private-sector R&D establishments as well as a National Computer Board were set up there. The Science Park also serves as an "incubator" for new units. Industrial development is supported by heavy investment in the informatics and telecommunications infrastructure - present levels of investment in the latter are comparable with those in the smaller EC-countries.

Foreign investment has always played a key role; of all ASEAN countries it is the most open to such investment, and the government provides a range of incentives. By the late 1980s, 64 out of 104 firms producing components, and 16 out of 25 industrial electronics firms were of foreign origin.[55] The industry is progressing to the production of sophisticated integrated circuits. A number of mainly US-owned industries have invested in this activity, and a joint venture of two US companies with the Singapore Technology Corporation has been set up for this purpose as well. Software development is another area where intensive co-operation with foreign firms exists.

Singapore, like the Republic of Korea, produces mainly for export markets. The major destination of exports in the USA, which absorbed 60 per cent of the country's output in the late 1980s.[56] Exports are dominated by computers, peripherals and other office equipment.

Wages in Singapore being the highest of all Asian NICs, the country's electronics firms have relocated a number of labour-intensive activities that

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[55]UNIDO 1989a, p.23.

[56]UNIDO 1989a, p.16.

do not require skilled labour to other Southeast Asian countries, primarily to neighbouring Malaysia.

Malaysia[57]

Malaysia is at a lower stage in the development of its electronics industries than the other developing countries reviewed here. The PRC's overall development level, in terms of per capita GDP, may be lower, but the sheer size of its economy and population have allowed this country to make more headway; the Chinese government moreover is in a position to demand concessions with regard to technology transfer from foreign companies attracted by its vast market. Foreign investors, attracted by low labour costs and generous incentives, have so far done little to promote progress in Malaysia's domestic industry - there are, e.g., few linkages between the many electronics companies located in the FTZs and local companies.

Although the Malaysian government encourages the development of domestic technologies, the country has therefore mainly been a basis for assembly operations based on imported materials so far. Where such operations are carried out by foreign companies (this is usually the case) the technological level tends to be high, as their products are meant for industrialized country markets. Local firms tend to use simple technologies.

The industry was long dominated by components manufacture, semiconductors in particular. In this industry, labour in increasingly being replaced by automated, micro-processor controlled equipment. Although semiconductor production is still rising, recent years have seen a shift in employment shares to the rapidly growing consumer electronics industry. Output of TV-sets has risen particularly fast, being almost eight times the level of 1980 in 1988.

Production is strongly export-oriented, accounting for 56 per cent of manufactured exports earnings in 1988. The USA is the major export market for components, while the FRG is the main buyer of consumer electronics. But NICs like Singapore and Hong Kong have also important destinations - probably of components for their electronics industries.

The development of the local industry could benefit from following a "niche" strategy in export markets for relatively unsophisticated products. Neither the very expensive state-of-the-art technologies nor mass production seem feasible for the domestic firms. Ways might be sought by the government to ensure a higher level of technology transfer by foreign investors, perhaps through joint ventures with local enterprises. The government could also directly stimulate local production through equipment purchasing schemes - provided that the local firms can "deliver the goods". Finally, efforts should be stepped up to improve training facilities for skilled workers and high-level technicians (or to stop their emigration to Singapore, by offering better employment conditions).

India

State intervention has played a prominent role in the industrial strategies for the electronics industry in India. The ultimate goal is "technological self-reliance", which however includes the adaptation of

[57] Based on UNIDO 1991d.

foreign technology where this is in the industry's interest. Several institutes are involved in R&D, some of them exclusively devoted to electronics, such as the Central Electronics Engineering Research Institute. According to one source, however, the country lacks a clear long-term strategy as well as a strong central development (as opposed to regulatory) agency.[58]

In contrast to the countries discussed previously, the government has not only provided support and a general framework for the development of the industry; it is also directly involved in productive activities. Public sector companies include ECIL, which is involved in computer design, production, marketing and maintenance as well as software development, and BEL and SCL which produce integrated circuits.[59]

While welcoming the contribution of foreign technologies to the growth of the domestic electronics industry, the Indian government has placed restrictions on foreign investment. Foreign firms are required to enter in joint ventures with local firms. Recently, policies with regard to investment, licensing, etc., have begun to change. Collaboration agreements have resulted in the transfer of a number of technologies, mostly from American firms.

Industrial electronics dominate production, accounting for 44 per cent of output by value in 1988; consumer electronics account for most of the remainder, and constitute the most rapidly growing segment of the industry. The output is basically intended for the large domestic market. SCL, e.g., supplies modules and electronic circuit blocks for watches and clocks assembled in India. A large-scale telecommunications modernization programme (in 1990, more than US$ 1,300 million was invested) has provided stimuli for the domestic production of a wide range of equipment.[60]

Although the industry has moved away from assembly of imported kits to products based on domestic R&D, there is a technological backlog in several key areas, such as semiconductors. Economic and technological constraints play a role here, and because of these constraints, the Indian government places few restrictions on imports of, e.g., microprocessors needed for the production of microcomputers.[61]

A very active policy has been followed with regard to software development and exports to English-speaking countries, on the basis of relatively cheap qualified labour. This policy was only successful after co-operation agreements with leading transnational corporations in the field. In 1987-88, exports amounted to Rs. 800 million.[62]

The industry is heavily centred around a few comparatively large firms, as in the countries above, small units being mainly engaged in assembly operations. But in contrast to a country like the Republic of Korea, the

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[58]The Hindu, 1990, p.135.

[59]UNIDO 1989a, p.20.

[60]The Hindu 1990, p.131.

[61]UNIDO 1989a, p.10.

[62]UNIDO 1989a, p.36.

range of products put out by the large firms is rather narrow. This is again related to the constraints referred to in the previous paragraph. Recent policies attempt to stimulate sub-contracting of large-firm production activities which do not require a high degree of sophistication to the small-scale sector.

The shortage of qualified labour is one of the major obstacles to future development of the Indian electronics industry. By the end of the previous Seven Year Plan, in 1990, this shortage was estimated at 80,000 persons. To remedy this situation, the government has initiated a number of programmes which should not only improve the availability of technicians and maintenance personnel in the industry with but which would also increase computer skills among students in secondary and tertiary education.[63] Such a broad approach is of great value in strengthening the role of informatics in the economy as well as in public life in general.

Brazil

Brazil has in past pursued a policy for the electronics industry that resembled the Indian policy: heavy emphasis on production for the large internal market (currently estimated at US$ 7,000 million), strictly regulated foreign investment, and a fairly strong presence of public enterprises in production. In contrast to India, domestic suppliers were more or less shielded from competition by a strict "market reserve" policy for informatics.

This policy has been criticized as being an obstacle to the absorption of up-to-date technologies and to price-efficiency, with, consequently, serious losses for the Brazilian economy. A new Technological Capability Programme (TCP) and Informatics Policy are to remedy this situation. Total R&D spending as a percentage of GDP is to increase from 0.5 per cent in 1990 to 1.3 per cent in 1994, with a greater share of private sector R&D, and better interaction among various partners: the government, private domestic enterprise, foreign enterprise and local technological institutes and universities.

Imports of digital technologies were allowed in October 1991. During the next few years, however, tariffs and taxes will still double the cost of imports; only in 1994 are tariffs to be reduced. Meanwhile, incentives are being provided to set up joint manufacturing ventures, and US firms such as IBM are strengthening their presence in Brazil. These joint ventures should stimulate the modernization of the industry by exposing Brazilian enterprises to state-of-the art technologies and production/management methods.[64]

For local industries, the opening-up of the market is likely to result in a major re-orientation. Activities that are thought to have a good growth potential include electronics-related services (distribution, marketing, technical support); assembly of imported components; and custom-made software. The latter could be particularly lucrative, as the number of computers as well as their sophistication is likely to increase rapidly. Finally, the country has embarked on a large modernization and expansion scheme for telecommunications which by 1995 could require investments worth

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[63] UNIDO 1989a, p.36.

[64] IDB, forthcoming.

US$ 1.1 thousand million.[65] This offers great opportunities for local producers who can provide the right type of equipment.

4. EUROPE'S UNIFICATION: THE CHALLENGE FOR THE DEVELOPING COUNTRIES

The electronics industry, as has been described, is not one in which developing countries have so far made significant impact, especially at the leading edge, the manufacture of components. The prospects for developing countries to increase their share of world electronics manufacturing are limited by the intense competition between producers in different developed countries. From this point of view, developments in the electronics industry as a result of the Single European Market are only part of much wider developments in which the competitive positions of firms in Japan, the United States and the European Community are the main issues. The impact of the Single Market as far as developing countries are concerned is in the short term a minor issues, although there are medium to long term effects which will certainly influence the prospects for developing countries in the future.

A complication in such assessment is the possible evolution of the present configuration of actors in the competitive electronics business. At the moment there is increasing divergence between the position of firms and of governments, especially in some European countries, but also in the United States. Issues of ownership and strategic alliances often cause conflict between companies and public policy makers. For instance, the acquisition of ICL, the UK Computer Company by Fujitsu has led to a re-consideration of ICL's membership of European research programmes and industry associations, because ICL's status as a European company was questioned as a result of the change in ownership. The new collaboration between Group Bull of France and IBM may be taken as a reversal to some extent of previous policy for a national industry in France, but it should be noted that permission for the partnership, as well as the choice of partner were determined at a very high policy level.

In general, it may be expected that international linkages, cutting across the traditionally competitive national/regional categories, will increase. This is not only because of the huge investment costs now needed for each stage of the industry. It is also because of the very high risks associated with such investments. Strategic alliances between electronics manufactures, hardware/software consortia etc. and the pressure for standards amount to an attempt to reduce the risk by setting limits to the area in which competition may take place. By so doing they can also be seen as agreements on the sharing of potential markets. These tendencies are likely to be increasingly accepted by governments, albeit reluctantly, since the alternative may be seen to be the disappearance of their own national companies.

The EC will have some moderating influence on this general tendency, because its expressed ambitions in terms of industrial competitiveness, together with a number of practical measures, will have the effect of encouraging partnerships, alliances and mergers within the European Community, to some extent limiting the scope for external alliances.

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[65] UNIDO 1989a, p.180.

These tendencies, reinforced by the general Single Market tendency towards larger firms, will lead to greater concentration in European and world industry. This conclusion is supported by the evidence on mergers and acquisitions in this sector referred to earlier in this paper. The R&D programmes of the EC, through their insistence on cross-border partnerships within the Community, may provide further impetus.

Concentration in the industry in developed countries will reduce in general the possibilities of competition from developing countries as far as components are concerned, as well as in telecommunications. There may be new opportunities however in terms of niche markets in other areas of industrial and consumer electronics, and developing country firms may find success with new hardware/software combinations that meet needs that have been overlooked by the large developed country producers. Such opportunities however will only be open to enterprises that are flexible, agile, innovative and in touch with their markets: these will be mostly their own countries and regions.

As regards investment trends, the European Community will increase in attractiveness as a location. The potential of the Eastern Europe market will also mean that such outward EC investment as takes place will increasingly be directed there, and the availability of skills and geographical position will tend to reinforce such a trend. A stronger European industry may however lead to later expansion in developing regions: this will be however more to be better placed for the local and regional markets than to take advantage of low wages for traditional assembly operations.

The development of standards, especially in the fields of telecommunications equipment but also commercial standards developed through alliances or market dominance will have on balance positive effects as far as developing countries are concerned. Certainly developing countries are not directly included in the consultative and decision-making processes, but the trend will be towards a more stable environment in which the development of products can take place. Since compatibility rather than quality standards are usually in question in the electronics field, the effect on investment requirements to meet them would not be so direct. The emergence of *de facto* commercial standards gives of course a competitive advantage to those who have the market power to impose them, but their proprietors nevertheless have an interest in seeing them widely adopted, and make information on them available accordingly.

On a related question of intellectual property, there may be increased emphasis on software protection, and this question will probably assume a larger place in trade negotiation. Pressure will come from the United States as well as European producers. Stronger measures against software financing in developing countries might provide a stimulus to local software producers in those countries and regions.

A relatively recent issue, which will no doubt become an important one in coming years, is the environmental impact of the production and disposal of electronics. There was no information on specific EC-legislation with regard to this issue in the field of electronics at the time of writing, but general legislation with regard to toxic substances would apply, and it is likely that such legislation will become tougher. Chemicals used in, e.g., the manufacturing of components have caused considerable environmental damage in the USA. Particularly important in this connexion is the use of solvents. Recent experience shows that preventing such damage is usually cheaper than "end-of-pipe" pollution control (see, e.g., Electronics 11/1991, 42-43). The

recycling of used computers, etc., ight perhaps also become a legal issue. Non-EC producers would have to take account of these developments, as non-compliance with relevant legislation may become an obstacle to entering the European market.

The most important characteristic of the electronics industry, which the Single Market will if anything enhance is its international character. The technology diffuses across national boundaries and offers because of its continually developing character, scope for innovations and new producers. It should not be forgotten that the first microprocessor was designed by Intel, but produced for them by a Japanese firm.

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