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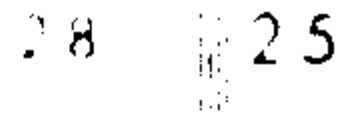
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MICROELECTRONICS AND THE DEVELOPMENT OF LATIN AMERICA: PROBLEMS AND POSSIBILITIES FOR ACTION*

* The attached document was submitted at the meeting under the above title, no. E/CEPAL/R.317, and was prepared by the ECLA/UNIDO Joint Industry and Technology Division, with Consultants Mr. Eugenio Lahera and Mr. Hugo Nochteff, Professor-Researcher of the Latin American Faculty of Social Sciences. This document has been reproduced without formal editing.

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INTRODUCTION AND MAIN CONCLUSIONS

1. Introduction

This study has been prepared for the UNIDO/CEPAL Expert Group Meeting on the Implications for Latin America of Advances in Microelectronics, to be held from 7-11 June in Mexico City.

Its main objective is to present some elements which may contribute to the study of the possible repercussions of the incorporation of these new technologies into the economic and social development of the Latin American countries, and also to advance some possibilities for action in this respect.

The study is thus of a rather introductory nature, and does not deal in depth with the diversity of situations and experiences found in Latin America, which is fundamentally based on the existing knowledge in the electronically more highly developed countries. It is hoped that a more complete future version, expanded by the discussions and conclusions of the Expert Group Meeting and by the additional research to be undertaken later, will answer certain basic questions being asked both by the Latin American countries and by the region as a whole with respect to the problems caused by the incorporation of microelectronics technology, as well as to possible paths that could be followed according to the characteristics and realities of the region itself.

One of the most basic of these questions is what really is the microelectronics problem from the point of view of Latin America and what are its possible responses. In addition, another of the questions to be clarified is what are the specific areas in which problems arise for the region due to the incorporation of microelectronics into their production processes and services, in order to identify the actions and policies which would be most suitable for the region as regards maximizing the beneficial potential of microelectronics and minimizing the negative aspects.

The study has three chapters, the first of which explains some concepts used in relation to the electronics complex. Chapter 2 analyses various aspects of the incorporation of microelectronics in Latin America, and chapter 3 presents some considerations on the possibilities for action in this area being offered to the countries of the region.

2. Summary of principal conclusions

The application of microelectronics is multisectoral and is having a varied impact on the economies of the industrialized countries. Although this progress tends to be considered as inevitable and very important, its effects have not as yet been fully recognized in Latin America; there is thus an urgent need to create an awareness of the subject.

The intensity of the effects and the type of consequences resulting from the introduction of microelectronic techniques depend on the characteristics of the economies of the countries in which they are applied and the public and private actions undertaken with respect to them. There are in fact significant differences between the countries of the North and those of the South, as well as among the countries of the South, with respect to the impact of microelectronics. The incorporation of this new technology in Latin America is the result of a rather disorderly and discontinuous process, whose forms and extent vary from one country to another. It is a markedly exogenous impulse, conditioned by research and technological advances mainly being made in the central countries and largely stimulated by the transnational corporations, which are the main providers of microelectronics; it is also characterized by the passivity with which it is being received in the majority of Latin American countries.

The principal demand for goods from the electronics complex comes from the public sector, largely because of the decisive importance of communications. The private sector, both national and foreign, is also important in the demand for consumer durables and capital goods for industrial, financial and service activities.

In relation to the change in comparative advantages resulting from the introduction and diffusion of microelectronics, although there are no sufficiently conclusive indications of this, the perceivable effect is already great enough to raise some doubts about the expectations of industrial redeployment and the continuation of exports of manufactured products, at least in certain industries such as electronic corponents and consumer goods, textiles and clothing. The analysis of future prospects of the industrialization of the region will thus have to take into account these new circumstances.

In respect of employment, the scarce and partial data available for Latin American countries do not warrant the categorical conclusion that microelectronics contributes to an increase in unemployment. Moreover, there are some indications

that the opposite result might occur, particularly in the sectors in which microelectronics could simultaneously raise productivity and employment, such as small and medium-sized companies and the so-called informal sector. In any case, the possible displacement of labour should be evaluated within a broader context, taking into consideration also the drop in the costs of investment and materials, characteristics of scale, flexibility and higher quality of goods and services produced, as well as the stimulating effect that microelectronics could have on the economy.

It is believed that microelectronics could contribute a great deal to the region, as long as some of the current forms of its incorporation are modified so that its potential can be sufficiently utilized.

Any action alternative of the Latin American countries with respect to microelectronics should be aimed at surmounting the above-mentioned exogenous character of its present incoporation. What is recommended is a selective endogenization, both because of the diversity of domestic situations and national objectives and because of the differential supply of resources and the impossibility of achieving simultaneous development in all areas.

There should thus be priority for national development objectives to which this technology can make a contribution. The main purpose would be to develop applications based on the available microelectronics, producing adequate software for the solution of problems in each of the countries. In very general terms, some objectives of interest could include: (i) advances applicable in the sectors of the economy where existing comparative advantages can be reinforced or priority social problems can be resolved; (ii) applications which would best exploit the existing comparative advantages within the electronics complex itself, and (iii) advances which make it possible to come closer to the basis of these microelectronic technologies, i.e., integrated circuits, commonly called "chips".

It is felt that the maintenance of a basic technological capacity is a prerequisite for successfully dealing with the selective endogenization of microelectronics. To reach such a capacity it would appear necessary to create domestic technology centres and firms, in order to acquire the necessary knowledge to obtain maximum benefit from these options.

The necessity of negotiating with the transnational corporations imparts a centralizing role of significant importance to the public sector. Moreover, an organic State purchasing policy is required to create demand for adequate applications.

The action possibilities with respect to the incorporation of microelectronics include a vast range of opportunities for international co-operation, especially at the South-South level. The similarity of the problems and needs being faced by the various groups of countries and the need to achieve basic scales and critical volumes should help to facilitate this collaboration.

I. THE ELECTRONICS COMPLEX

1. The concept of the electronics complex

During the past decade people have begun to speak of a new industrial revolution induced by the massive application of electronics, which is the industry that has grown most throughout the world since 1945 1/ and has become a convergence industry, irradiating innovation and permeating all other industries and many services.2/ On the one hand, the impact of electronics depends primarily on the development of microelectronics technology,3/ whose basic unit is the integrated circuit, which has penetrated existing products and made it possible to create new ones. On the other hand, however, microelectronics influences and is influenced by other technological developments.4/ These developments, the industrial sectors which manufacture their products and the highly specialized human resources they require together make up what has been called the electronics complex. It is important to note that microelectronics is the catalyst, but not the whole of this technological-industrial complex. In actual fact, in 1979 the microelectronics industry represented 5% of the value of the products which contained 5/ integrated circuits. The value of sofware 6/

1/ UNCTAD, Electronics in developing countries: Issues on transfer and development of technology, United Nations, 1978.

2/ Juan Rada, The impact of microelectronics and information technology with reference to Brazil, Argentina and Bolivia, UNESCO, 1980.

3/ D.H. Roberts, "Microelectronics and its application", CEC Journal of Science and Technology, Vol. 46, No. 3, 1980.

4/ Such as lasers, optical fibres, printing and display technologies, etc., see UNIDO Secretariat, Implications of microelectronics for developing countries: A preliminary overview of issues, UNIDO, Vienna, 1981.

5/ UNIDO, op. cit.

6/ Originally "software" referred to the operating instructions which are given to a computer so that it will perform certain tasks (such as complicated mathematical calculations or the preparation of payrolls) and "hardware" to the physical support to which the instructions are given or to a set or system of sets made up of electronic components, mechanical parts and the like. More recently the meaning of software has been extended to include, generally speaking, all the engineering needed to obtain a product or a function from an integrated circuit, a set of integrated circuits or a system made up of existing sets. In this study the word will be used in this full meaning and "utilization software" will be used only in the more limited meaning. It should be noted that there is no clear dividing line between software and hardware. In the case of some integrated circuits (microprocessors), the instructions are recorded physically. Owing to the (cont.)

was much greater,7/ and in many cases (data processing systems, for example), its share in the total cost is growing. The expression "electronics complex" has been preferred over "electronics industry" for the reasons mentioned and also because the application of these technological developments has meant that a large proportion of the manpower specializing in electronics is engaged in other economic activities.8/

2. Main recognized effects

During the next quarter of a century the electronics complex will be the main pole around which the productive structures of the advanced industrial societies will be reorganized.9/ The reason for this has been summarized in abstract terms, in the statement that no mechanical or intellectual activity can take place without some form of information exchange and that microelectronics has succeeded in creating a comprehensive system for handling information.10/ This is resulting in the incorporation of solutions based on microelectronics in an enormous range of products and services, from the improvement of products (automobiles) to the radical transformation of their composition and cost and the services they provide (computers) or the creation of new products (word processors). In some cases (watches, for example), not only the composition of the product but also the industry which manufactures it has been transformed. An exhaustive list of the applications would take up too much space and has been repeatedly attempted in the

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6/ (concl.) accelerated reduction in the cost of integrated circuits and the rise in that of software production, an attempt is being made to incorporate increasingly detailed instructions into integrated circuits so as to mass-produce them with as much software as possible physically included. This has resulted in the invention of the word "firmware" to refer to integrated circuits which incorporate more of the "intelligence" that software provides.

7/ It is calculated that between 1975 and 1980 1 billion dollars worth of software was used in the applications of the INTEL 8080 model (see R. Chopra and P. Morehouse, Frontier technologies, developing countries and the United Nations system after Vienna, UNITAR, New York, 1981). This is equivalent to 2.5 times the INTEL company's turnover in respect of all its models in 1979.

8/ UNIDO, op. cit.

9/ OECD, Interfutures, Paris, 1979.

10/ Juan Rada, The impact of microelectronics, ILO, Geneva, 1980.

literature on the subject.11/ Attention will be drawn here to only a few widely recognized effects which are most relevant in connexion with the identification of the problems and possibilities which the electronics complex presents in respect of Latin American development.

Microelectronics has shown a great capacity for replacing parts and mechanisms since potentially (and within certain limits) any product that uses springs, levers, stepping motors or gears is performing logical functions and could therefore be built of semiconductors.12/ This makes it possible to reduce the number of parts significantly, with multiple effects on the direct and indirect costs, the size of the plant, the expenditure of energy, and product reliability. The resulting miniaturization makes it possible to introduce new functions and/or to increase the volume of existing products marketed. The former is illustrated by the introduction of numerically controlled machine tools, and the latter by the number of micro-computers. Product differentiation is thus of growing importance where traditional products, such as automobiles, television sets and telephones, are concerned. The production process is also affected in various ways: not as much skilled labour is required, the number of firms supplying specialized products plummets dramatically, and the end producer's capacity to "untie" the technological package is reduced because an integrated circuit, which, to the producer is a "black box", replaces dozens and sometimes hundreds of parts produced by more accessible technology. In addition, information on the existing integrated circuits and their applications and the ability to produce software to make use of them is constantly increasing. The penetration of microelectronics into capital goods is also having a significant impact on the manufacturing process. At present integrated circuits are applied in the performance of the following tasks: the controlled movement of materials and products; the control of process variables such as temperature, humidity and pressure; the cutting, shaping, mixing and

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11/ See, inter alia, Tom Forrester (ed.), The microelectronics revolution, Basil Blackwell, Oxford, 1980; J.H. Westcott, "Application of microprocessors" in Tomorrow in World Electronics. A Financial Times Conference, Grosvenor House, London, 1979; H. McLean, The Electronics Industry (Technical Change and Economic Policy Series), Paris, OECD, August 1980.

12/ Kvamme Floyd, quoted in S. MacDonald, D. Collingbridge and E. Braun, "The case of semiconductors", Bulletin of Science and Technology Society, Vol. 1, Pergamon Press, USA, 1981, p. 312.

moulding of materials, the assembly of components and subassemblies; quality control, and the organization of the manufacturing process (design, stock-keeping, dispatch, maintenance, allocation of tasks, etc.).13/ In general, the improvements obtained are similar to those already mentioned regarding product change and include, for example, higher levels of automation. Special attention may be drawn, however, to the following results:

(i) Reduction in the time needed for design and the rechannelling of ideas among the areas responsible for design, production, quality control and administration, through the application of computer-aided design/computer-aided manufacturing (CAD/CAM) and the integration of those areas, when computerized, into the Integrated Business System (IBS).14/

(ii) Simultaneous increase in the yield of capital and labour, although not in all cases.

(iii) Greater flexibility introduced by incorporating an increasing amount of "intelligence" and the possibility of incorporating it in small machines at low cost, enabling the use of advanced techniques in small and medium-sized firms and in artisanal-type work.

One of the most important features of the electronics complex is that it is causing the automation of office tasks, which had barely been touched by the old technologies, to soar. This is due not only to the availability of office machines (including computers) whose ability to store, process and distribute information is increasing spectacularly, but also to the no less spectacular reduction in their cost and size.15/ In addition to the impact described above, there are the possibilities of introducing these machines into small service undertakings.

The "marriage" of telecommunications and informatics has such important and many-sided reactions that much of the literature on the electronics complex is concerned with it. For the purposes of this study, the following points are considered to be especially relevant:

13/ J. Bessant, E. Braun, and R. Mosely "Microelectronics in manufacturing industry: The rate of diffusion", in Tom Forrester (ed.), op.cit., p. 14.

14/ ACARD, Computer Aided Design and Manufacture, HMSO, London, 1980.

15/ From 2 542 kg to 0.30 kg and from US$ 200 000 to US$ 300 in 23 years, at nearly equivalent performances, by the IBM 650 and the TI-59. (Juan Rada, op. cit.).

(i) The growing share of informatics and telecommunications in investment;

(ii) The increasing concentration of informatics in the more highly developed countries;

(iii) The opportunities which the new technologies provide for nations where a large proportion of the population lives in rural areas and small towns;

(iv) The increased availability of data on weather conditions, crops, monetary flows, international prices, etc., which can be obtained faster, in greater detail and less expensively.

The impact on monitoring systems and equipment and instruments of measurement in general has already been covered in the comments on manufactures and manufacturing, but it is nevertheless worthwhile drawing attention to the great increase in opportunities for obtaining more plentiful and exact information on mining and agriculture and to the possibility of making the functions of medical apparatus more complex, thus relieving the need for professionals and making it possible for the field of health to be manned by people who spend less time in training.

One characteristic of the electronics complex whose consequences and potential with regard to development have not been sufficiently weighed is that the main instigator of its progress was originally and to a considerable extent continues to be the military and aerospace sector. This means that there is a big gap between the potential uses of integrated circuits and their actual applications in civilian life. This gap is still big and its main implication is that a lag in the field of microelectronics must not necessarily be accompanied by an equivalent lag in the applications.16/

The vast number of sectors affected by the electronics complex, the big impact it has and the complexity of the intersectoral relations it creates tend to make it increasingly difficult for both enterprises and governments to assess the direct costs and benefits of the investments for purposes of decision-taking. Consequently there is a need to make technological data more readily available, to initiate a continual planning process, to consider the indirect and long-term effects of economy policy decisions, and to increase the co-ordination of public policies.

16/ This is particularly important for the developing countries because, although it is true that the technological frontier has been expanding very rapidly where the more sophisticated integrated circuits are concerned, this expansion has been much less dynamic with regard to a wide range of applications.

II. THE REGIONAL SITUATION

1. The Latin American point of view

Not surprisingly, most of the literature on the impact of microelectronics relates to the situation in the developed countries. When it is sought to analyse the impact on the countries of the region from this point of view, we soon discover that the studies referred to cannot be transposed automatically to the Latin American scene.

All the countries in the region are being affected, to various degrees and in different ways, both by the dynamism of the electronics complex in the developed countries and by the incorporation of microelectronics in their own economies. We cannot, therefore, continue to ignore this subject without prejudicing Latin American development in the not too distant future.

The diversity of individual situations conditions and transforms (sometimes decisively) the effects of the incorporation of microelectronics. A research and analysis effort is therefore necessary in order to understand the real situation, which is the essential basis for making sound proposals for any development strategy. There is need for an explicit Latin American point of view, and the attempt to find one calls for the collective labour of the various persons and institutions in the region.

If utilized correctly, microelectronics may be of considerable help in solving the central development problem of Latin America, such as the asymmetry in the structure of external relations, the fall in the growth rate of most of the countries and the development of extremely inequitable societies.17/ By itself, microelectronics neither leads to nor stands in the way of development, but it is essential to recognize that it may either add strength to a national development strategy or aggravate the problems now faced by the region.

This chapter contains a description of some of the ways in which microelectronics can cause problems for the development of the region. Because of the lack of specific and detailed information on the topics considered, many of the conclusions advanced are still hypothetical, and further research is needed in order to verify them.

17/ CEPAL, Regional Programme of Action for Latin America in the 1980s, "Cuadernos de la CEPAL" series, No. 40, 1981.

2. The incorporation of microelectronics

The electronics complex in Latin America has grown by leaps and bounds under a markedly exogenous impetus in which the transnational corporations have played a decisive role. The TNCs have contributed decisively to the development of microelectronics technology and to its application in specific products and are the biggest and most dynamic suppliers of goods produced by the electronics complex at the world level. In addition to imports, the Latin American supply includes locally produced goods with a microelectronic component. The TNCs normally play an important role in this local production and frequently dominate the market. In Mexico, six TNCs control the informatics market, and one of them -IBM- accounts for 55% of the total, followed by Honeywell with 15%.18/ In Chile the seven biggest TNCs control nearly 95% of the market, IBM being in the lead with a share of 25%.19/

The region's largest demand for goods from the electronics complex comes from the public sector. This is due to its decisive role in telecommunications, its big demand for data processing equipment (in Mexico, for example, over 50% of computer sales are to the public sector,20/ and similarly, over 50% of IBM's sales in Latin America are to that sector),21/ and the importance of military expenditure in most of the countries in the region.

Private firms, both national and foreign, in the industrial, financial and service sectors also account for a considerable share of the demand for durable consumer and capital goods.

Both the supply and the demand profiles which emerge determine the rate and the ways and means of incorporation of microelectronics, with the public sector and the TNCs playing the leading roles in this.

The incorporation of microelectronics in the region has been and still is a heterogeneous, irregular and unordered process and takes place by means and to degrees which vary from country to country. In some countries the electronics sector is quite developed, while in others it is still incipient; some countries import a large proportion of the products of the electronics complex which they need

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18/ Ministry of Planning and the Budget, Política informática gubernamental, Buenos Aires, 1980.

19/ The Economist Intelligence Unit, Quarterly Economic Review of Chile, third quarter, London, 1980.

20/ Latin American Weekly Report, "Entering the microcomputer age", London, 20 November 1981.

21/ Robert Bennet, "IBM in Latin America", in Jon Gunnemann (ed.), The nation state and transnational corporations in conflict, Praeger, New York, 1975.

and others, not so many; and some countries even export electronic goods. Per capita consumption of goods produced by the electronics complex fluctuates considerably, and capacities for producing and adapting complicated goods or components also vary widely.

In addition, the countries of the region also differ significantly in terms of their strategies for incorporating microelectronics. While freedom to import is the general rule in some of them, in others an attempt is made to rationalize importation by aligning it to pre-established patterns; in some countries the national electronics industry is protected or promoted, while in others it is often actually discouraged in practice; a number of countries have general or specific laws on TNCs, while in others the attitude toward foreign investment tends to be liberal.

3. The productivity gap

The difference between the developed countries and the countries of the region in respect both of the speed of incorporation of the innovations generated by the electronics complex and of the capacity to adapt them to the national economies may widen the existing productivity gap.

This would occur as a result of the increase in productivity brought about by applying capital goods with microelectronic components in the manufacturing sector, but it is also due -and perhaps even more so- to the possibilities of dramatically increasing the productivity of the services sector and to the global impact of the improvement in data processing and communication systems.

It is also necessary to take into account the consequences of improving and differentiating existing products through the incorporation of devices based on microelectronics. Greater factor productivity and product differentiation may combine to force the goods produced in the region out of the markets and thereby lower national income. These are some of the reasons most often invoked in the developed countries for furthering the incorporation and development of the electronics complex in their economies. The Advisory Council for Applied Research and Development of the United Kingdom summarized the position by stating that if the country neglected or rejected this technology, it would join the ranks of the underdeveloped countries.22/

22/ Quoted in Juan Rada, "The microelectronics revolution: Implication for the third world", Development Dialogue, 1981:2.

4. Changes in comparative advantages

It has been argued that microelectronics will have a big effect on comparative advantages, eroding those based on low labour costs and enhacing those due to greater scientific and technological development.23/ By way of example, attention has been drawn to the growing capital-intensiveness of industries and processes which were previously labour-intensive and to the drop in the share of wages in the cost of some capital goods.24/ The main result of these changes, it is said, will be modification of the expected trends in industrial redeployment.

This modification seems already to be reflected in certain attitudes. As might have been expected, microelectronics itself seems to have been the first to profit extensively from its own innovations. Thus, the work involved in the assembly of semiconductors no longer flows from the more highly developed countries to countries where labour is cheap, and certain electronic assembly industries have returned to their countries of origin. During the period of transition, while this process is underway and the application of the production technologies which will make it possible to recover comparative advantages is being developed, the developed countries may increase protection. This seems to be what is happening in some sectors of the textile and television industries in the United States.25/

Similar reverse flows are in operation in connexion with telephone and office equipment. Olivetti withdrew its plants for the manufacture of sophisticated office machines from the region, as will be discussed in detail in Section 8 of

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23/ See, for example, J. Rada, The impact of microelectronics and information technology with reference to Brazil, Argentina and Bolivia, UNESCO, 1980, especially pp. 27-37; R. Kaplinsky, "Microelectronics and the Third World", Radical Science Journal, Vol. 10, No. 37, 1980, and K. Hoffman and H. Rush, "Microelectronics, industry and the Third World", Futures, August 1980.

24/ In telephone exchanges the share of wages in production costs falls from 40% to 20% when electromechanical technology is replaced by electronics; in the case of the lathes, it falls from 30% to 17% when numerically controlled lathes are used instead of standard ones (see S. Jacobsson, Strategy problems in the production of numerically controlled lathes in Argentina, Buenos Aires, 1981 (unpublished)).

25/ This kind of approach was recently taken by Zenith in defending the protection of the television industry in the United States through agreements limiting imports from Japan and other Asian countries.

this chapter. In the telephone industry, import substitution is being reversed through the replacement of electromechanical exchanges with semi-electronic and electronic ones. In the former, a high level of integration of parts from the region had been reached, but nearly all the electronic components 26/ used in the new exchanges are imported. The same is true of the software used in these systems.

These findings are still not sufficiently conclusive to support the thesis that there will be a drastic change in the patterns of industrial redeployment as a result of the development of the electronic complex. This has already had enough of an impact, however,27/ to give rise to doubts as to what to expect from industrial redeployment, at least in some industries such as those producing electronic components and consumer electronics, textiles and wearing apparel.28/ The impact of microelectronics on comparative advantages may make the increase in local value added, employment and industrial integration and other positive effects of redeployment less viable. Consequently, analyses of the prospects for industrialization in the region must take these new considerations into account.29/

5. More employment or less?

In the literature on the impact of microelectronics, attention has repeatedly been drawn to the unemployment which has resulted from the labour-saving aspects of the new technology in both developed and developing countries. This is a very popular topic in the developed economies because of the growing unemployment they face. In the case of the Latin American countries, however, the evidence for it is sparse and incomplete and does not categorically lead to the conclusion that microelectronics causes unemployment to rise. There is even evidence that the opposite may be the case.

There can be no doubt that this technology leads to unemployment in those cases where the goal is not so much to expand the volume of production as to rationalize the production process, which will normally tend to lower wage costs.

26/ In particular the integrated circuits replacing the electromechanical parts formerly produced in the region.

27/ UNIDO, Redeployment of industries from developed to developing countries, 1982.

28/ Ibid.

29/ Ibid., especially pp. 11-12.

The automatic body-welding machinery installed by Ford in Brazil requires four workers to do the work previously done by sixty, and it is highly likely that the same will be true, on an even larger scale, when robots are introduced in the Volkswagen production line in the same country, by 1984. It should be noted that this is an industry with problems and that it is in a process of complete reorganization throughout Latin America and the world.

There are, however, also sectors in which the introduction of microelectronics could boost both productivity and employment. This is true of the small and medium-sized firms which might require more labour if they had more production equipment which was relatively cheap, simple and easy to maintain and repair,30/ as happened when electrical machinery was first introduced. The same can be said of a good part of the informal sector, particularly if appropriate applications of microelectronics are developed in such areas as the improvement of powered hand tools.

From another perspective, it may be noted that the labour force employed in the information sector is growing more rapidly than the labour force as a whole (at least in some countries of the region), making it a dynamic source of employment. In the case of Argentina, the proportion was 17% in 1947, 24% in 1970 and may now be about one-third of the total.31/

In addition, there are significant differences among the various countries of the region, both in their level of development and in the dynamism and characteristics of their growth, which will undoubtedly condition the impact of microelectronics. From another point of view, the pre-existing social situation will also be very important in terms of both the composition and the quality of the labour force. In this respect, it has often been pointed out that women and young people would be most affected.

The applications of microelectronics may affect the different levels of required labour skills in different ways. Skilled labour would probably tend to be replaced by robots, highly skilled workers by numerical control machine tools, and engineers and other professionals by computer-aided design/manufacturing equipment.

30/ G. Friederichs, Microelectronics, a new dimension of technological change and automation, 1979 (unpublished).

31/ Pablo Gerchunoff and Hugo Nochteff, Lecture at the seminar, "La Oficina del Futuro", Institute of Electrical and Electronic Engineers, Buenos Aires, 1980.

In general, changes will occur in the skills required of the labour force. The introduction of microelectronic technology produces a polarization of employment between semi-skilled operators and highly skilled technical personnel, with a decrease in employment for skilled manual workers.32/ There will also be some deterioration in manual labour, which will become more repetitive and frustrating.

An important angle for the evaluation of this problem is the economic growth which may be achieved by introducing microelectronics. This is because in given conditions of the utilization of the advantages of technical progress the accelerated growth of an economy may raise the standard of living of the entire population. The displacement of labour should be considered, however, within a broader context which takes into account the lower cost of investment, materials, characteristics of scale, flexibility and higher quality of goods and services.33/

6. The public sector

(a) Public administration

Microelectronics offers solutions for a series of problems which have arisen at the various levels of public administration, especially in the processing of massive information relative to its various functions, as well as in planning processes. This would require the introduction of microelectronics in a rationally planned and implemented way: something which, with alarming frequency, has not been the case. In the case of Mexico, for example, more than 20 firms had installed more than 340 different models of data processing machines -many of them mutually incompatible- by the end of 1979.34/ This situation also occurs in the other countries, with some variations.

Modern data processing systems have not necessarily improved the services offered by public administration. In practice, all that often happens is that the existing procedures are speeded up, without getting rid of the old bureaucratic practices. The costs of processing information are often passed on to the users, who, in addition, often have difficulty in correcting possible errors in the

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32/ ETUI, The impact of microelectronics on employment in Western Europe in the 1980s, Brussels, 1980.

33/ Rafael Kaplinsky, op. cit.

34/ Ministry of Planning and Budget, Mexico, Diagnóstico de la Informática en México/1980, p. 116.

information incorporated into the systems. The possibility of such error, in turn, continues to grow because of a tendency for an administration to rely basically on the information already stored into its records.35/

The enormous potential offered by microelectronic technology for the processes of planning has not been fully used either, and in some cases there is even a deterioration in the level and quality of the information published. Economic and social information tends to become private, creating differential opportunities to benefit from its use.

(b) Military expenditure

Microelectronic technology is a basic part of modern military equipment.36/ The marginal superiority of this equipment is frequently based on the incorporation of more advanced microelectronics, with high levels of technological obsolescence. These facts contribute to the incurring of higher costs by governments, for the purchase of arms and military equipment, which are largely imported from a few centres of production of these goods.

These imports increased between 1967 and 1976 from US$ 270 million to US$ 770 million (in 1975 dollars), which raised the Latin American share of the world total from 3.4% to 6% during the same period.37/

In cases where the domestic production of arms containing electronic parts has made some progress, these parts are almost entirely of foreign origin.

(c) Monetary policies

The growing facility with which the incorporation of microelectronics makes it possible to transfer funds may affect the supply of money within an economy. Banking customers with computerized systems can manage their balances with greater precision in order to reduce the quantity of money required for their needs. In countries with high rates of inflation this creates unequal opportunities for corporations of different sizes, to the detriment of the small ones. Generally speaking, the speed

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35/ Klaus Lenk, Societal implications of information technology, International Social Science Council, undated.

36/ Henrique Rattner, "Considerações sobre o impacto da microelectrônica nos paises latinoamericanos", preliminary version, First Latin American Seminar on the Socio-economic Impact of Microelectronics in Latin America, Buenos Aires, 1981.

37/ U.S. Arms Control and Disarmament Agency, World military expenditures and arms transfers, 1967-1976, Washington, 1978.

of circulation of money can be increased and made more variable, and all these developments can make it more difficult to maintain a stable relationship between the supply of money and the monetary base.38/ "Electronic money" is today a reality.39/

There is also an international dimension to this problem, since various economic agents may establish direct relations with the different world financial centres and carry out transfers of funds with them by various electronic methods. It has been pointed out that banks are becoming financial information enterprises at the world level.40/

From another perspective, systems for processing monetary information may significantly contribute to the design and implementation of the various aspects of means-of-payment policies.41/

7. Inadequate utilization of the electronics complex

(a) Underutilization

Underutilization of the goods and technologies produced by the electronics complex is one of the main problems arising from the conditions in which they are being incorporated in Latin America.

The case of informatics is the most clear, due to the existence of specialized centres in many countries of the region which facilitate documented evaluation of the problem.

The incorporation of computers and related systems in Latin America has occurred as a result of exogenous forces. The suppliers of computers set out to conquer the market by imposing products for which there was no local demand, offering solutions to "problems" which they themselves identified.42/ This process produced:43/

38/ Marjorie Greene, "Will technology undermine today's monetary control techniques?", The Banker, August 1981.

39/ J. Ricardo Tauille, Introductory notes to the political economy of information, unpublished manuscript, 1981.

40/ Arthur Ryan, Vice-president of the Chase Manhattan Bank, cited in Euromoney "Banking Technology: The New Frontier", January 1982.

41/ See Banco Central de Brasil, "La política de informática del Banco Central de Brasil", Monetaria, Vol. II, No. 4, October-December 1979.

42/ Política Informática Gubernamental, Ministry of Planning and Budget, Mexico City, 1979.

43/ See "Situación actual y tendencias futuras de la informática en el sector público", Informatics Section, Planning Department, Argentina, 1982; Recursos Computacionales Brasileiros, Computadores Instalados, SEI, Brasilia, January/February 1981; Ministry of Planning and Budget, Mexico, op. cit.

(i) a very high demand, unrelated to the real needs of the users or the objectives of utilization of the system;

(ii) a sharp disjunction between the equipment and manpower resources required for the above; and

(iii) a disorganized information system, with a proliferation of models out of proportion to its size, so that, for example, in one of the largest consumer countri of the region there were 142 models for 230 public administration bodies, mostly incompatible with each other.44/

As a result, the three largest customers of the region (Argentina, Brazil and Mexico) are having serious problems in utilizing the equipment. On the one hand, there is a serious quantitative underutilization, which amounts in a large number of cases to 45-55% of capacity 45/ and enormous maintenance difficulties.46/ In the case of Mexico, it has been observed that the impossibility of independent maintenanc of such a large number of models results in a certain limitation of the local information industry.47/ On the other hand, possibilities are restricted for developing new applications, especially those aimed at the "real needs of the user and the possibilities of the community",48/ despite the potential of the three countries for creating software. In the case of Chile, the number of processing unit grew from 100 in 1974 to 600 in 1980, without an equivalent expansion in the utilization capacity.49/

The limitation of local software is perhaps the most negative consequence of the way in which technology has been incorporated, not only because of the frustration of possibilities for adapting the systems to the users, but also because software already represents nearly 90% of the total cost of data processing systems at the world level.50/

44/ Ministry of Planning and Budget, Mexico, op. cit.

45/ Argentine Planning Department, op. cit.

46/ See I. Da Costa Marques, Racionalização dos contratos de Manutenção, in Boletim Informativo CAPRE, Vol. 5/1, January-March 1977.

47/ Ministry of Planning and Budget, Mexico, op. cit.

48/ Argentine Planning Department, op. cit.

49/ The Economist Intelligence Unit, op. cit.

50/ William Baker, Analysis of microprocessors business, National Semiconductor Co., undated.

In this respect it may be observed that the level of development of software for each level of microelectronics is considered one of the most important indicators of the degree of utilization of technology.51/

In view of the relationship between national data processing development and the degree of utilization of the facilities installed, it may be stated that underutilization in Latin America as a whole is even more serious than in the three countries mentioned.

Although information is not available on the level of utilization of other goods and technologies of the electronics complex, the fragmentary information that is available would indicate that the problems described are just as serious in most of them.52/

(b) Cost of use

The advantages of the incorporation of capital goods from the electronics complex, or of the incorporation of integrated circuit devices into existing capital goods, are counterbalanced in the countries of the region by the growing cost of use, including the cost of acquisition, installation, adaptation, training and maintenance.53/

The cost of use increases with the complexity and interrelationship of the equipment (systems such as CAD/CAM). In a system of industrial process control based on integrated circuit technology, "the cost of acquisition may amount to only 30% of the cost of use".54/

The less the knowledge of the technologies and production connected with the electronics complex, the greater the cost, and this tends to be greater in the countries of the region than in the countries of origin of the technology, adversely affecting the marginal efficiency of the equipment thus incorporated.

51/ See, for example, I. Barron and R. Curnow, The future with microelectronics London, 1979.

52/ For example, in computer-aided design/manufacturing (CAD/CAM) systems, electronic private telephone plants, numerical control machine tools, highly complex medical equipment such as computerized tomographs, etc.

53/ This concept and its importance in relation to the electronics complex have been defined in INTI and BMFT, Estudio sobre el desarrollo de la industria electrónica argentina, Conclusiones, Fase 2, Munich, 1981, Section 3.1.1.

54/ Ibid., p. 48.

8. Transnational corporations

The growing introduction of microelectronic technology will have an effect on one of the advantages offered by the developing countries for the transnational corporations -low labour costs- 55/ and this could reduce the flow of direct investment to these countries. However, this effect will be different in the various sectors, according to capital intensity and cost structure, and also will depend on other factors such as access by TNCs to raw materials and energy, or to new markets.56/

In addition, the introduction of microelectronics into products and production processes, may lead to significant changes in the international division of labour of the TNCs, which in turn may have an important impact on the host countries.

In the case of office machinery, these corporations show a high degree of specialization at the regional level which has been expressed in international production and marketing agreements, as well as regional integration machinery such as the Complementation Agreements.57/ For example, Olivetti specialized its Argentine plant early in the 1970s in mechanical calculating and accounting machines while it reserved its plants in Brazil and Mexico for typewriters. With the increasing pressure of microelectronics in the office machine industry, at the beginning of the second half of the decade, the firm reserved the production of new products for its plant in Harrisburg (United States), and the traditional production was moved to satellite plants, from which the regional market was supplied with the help of integrationist machinery. By the end of the decade, the demand for office machinery disappeared and Olivetti decided -in 1980- to redesign

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55/ In 1977, the subsidiaries with majority ownership by United States TNCs in the industrial sector were paying an average of US$ 6.34/hour in the developed countries and US$ 2.17/hour in Latin America. U.S. Department of Commerce, U.S. Direct Investment Abroad, 1977, Washington, 1981, table III.G.24.

56/ Latin America's share in direct foreign investment dropped from 14% to 13% in the case of Germany (1977-1979) and from 18% to 15% in that of Japan (1975-1979). In the case of investment from the United States, however, the region's share increased from 18% to 19% between 1975 and 1979. Sources: Survey of Current Business, Ministry of Economy of the Federal Republic of Germany, and Economic Co-operation of Japan.

57/ Eugenio Lahera, "La división internacional del trabajo de las empresas transnacionales y los Convenios de Complementación de ALALC", Problemas del Desarrollo, 39, 1978.

its plant in Argentina, limiting it to the production of electronic calculators for the domestic market, with only a low content of domestically-produced parts. The plant finally closed in 1981, the number of persons employed having by that time already dropped from 1 840 to 150.58/ Thus, the impact on the industry, technological development and domestic employment changed substantially in one decade.

From another point of view, the concentration of strategic decisions in the TNCs headquarters may assume new dimensions as a result of the incorporation of microelectronics, accelerating the potential loss of domestic control over the activities of the subsidiaries.

9. External trade in electronic products

The quantitative effect of the dissemination of the electronics complex may pose problems for the regional merchandise trade balance. This is especially clear in the case of the trade in electronic products. On the one hand, imports tend to rise dramatically. Between 1974 and 1978 they grew from US$ 1 391 million to US$ 2 172 million, an increase of 52.2% in only four years. On the other, the trade balance is definitely negative. In 1977, the foreign trade of the region in electronics amounted to US$ 2 139 million, and the deficit was US$ 1 469 million or 69% of total trade.

The quantitative results of foreign trade differ markedly according to the degree of electronic development of the countries, and especially their industrial and technological capacity.

This can be seen by comparing the data collected from Argentina, Brazil and Mexico with the data for Latin America as a whole. In 1979 these three countries imported 92% of the integrated circuits imported by the region:59/ a clear indicator of their industrial and technological capacity.

58/ Edgardo Cohen, Modificaciones provocadas por la microelectrónica en el rol de las empresas transnacionales electrónicas en los países en vías de desarrollo. Análisis de dos casos en el área de máquinas de oficina. First Latin American Seminar on the Socio-economic Impact of the Microelectronics Technology, Buenos Aires, 1981.

59/ Developed on the basis of United Nations, Bulletin of Statistics on World Trade in Engineering Products, 1979, 1981.

In 1977 these three countries represented 96% of Latin America's electronics exports, 57% of total trade, 50% of imports and only 40% of the deficit.

The difference in impact according to the degree of capacity to utilize microelectronics is not only quantitative but also qualitative. The countries with greater capacity in this technology dedicate a much higher percentage of their imports to capital goods.

In 1979, the three countries mentioned represented 76% of imports of data processing equipment, 72.4% of imports of telecommunications transmitters and receivers, and only 44% of imports of the principal electronic consumer devices.60/

10. Flow of information to the exterior

There are various ways in which the flow of information to the exterior may present problems for the countries in which this information originates. This may affect production and markets as well as financial transactions. The advantages of timely and systematically processed information -which in itself is a commodity and a profit-generating good- are generally obtained by the TNCs through their own information systems or through the use of other devices.

Penwait of the United States, for example, uses a system of data transmission by satellite to monitor the value of the currencies of the countries where it operates in relation to the dollar, in order to optimize its gains in relation to these fluctuations. Another United States TNC, ARMCO, uses the same type of information system, which enables it to acquire or sell the required currencies at the right moment.61/ There are between 100 and 150 of this type of information network.62/ In addition in the strictly financial area, besides the networks of the big banks there is SWIFT (Society for Worldwide Interbank Financial Telecommunications), to which only five Latin American countries with Singapore and Hong Kong, among the developing countries, belong.63/

60/ Ibid.

61/ Andrew Lloyd, "Précieux atouts pour les sociétés multinationales", Le Monde Diplomatique, December 1980, p. 13.

62/ Jean-Pierre Chamoux, "Monopoles nationaux et contraintes extérieures", Le Monde Diplomatique, December 1980, p. 15.

63/ Armand Mattelart, "L'Informatique dans le Tiers-Monde", Le Monde Diplomatique, April 1982, p. 15.

From another perspective there is the case of the United States Commodities Corp., a futures marketing firm for products such as pork fat and livestock, of which it may hold no inventory at all. Its main resources are the model-generating and predictive ability of its staff and the basic information it receives from Reuter's Worldwide Commodities Service, which transmits 5.1 million bits per second (a conventional telephone line only transmits 4 800).64/

Moreover, when the outflow of information is not subject to any restrictions and this permits indiscriminate telesoftware (the transmission of software over telecommunications systems), the possibilities of achieving domestic development of software practically disappear.

Denmark has regulated the collection of basic information designed to be automatically processed abroad, and Norway controls the outflow of this type of information.65/ In the case of Brazil, government policy has tended not to permit the indiscriminate flow of information abroad, and an international centre for the distribution of information is being formed which will provide for selective access to this information.66/

Access by developing countries to data banks located in developed countries relative to a wide variety of subjects may contribute to the development of Latin America, if the region develops the necessary capacity for their optimal utilization and if access to them is not selectively restricted.

11. Privacy and security of persons

At the international level there is serious concern for the various ways in which microelectronics might affect the privacy and security of persons. OECD, the Council of Europe and the European Economic Community, for example, have adopted measures to protect privacy.67/ Within Latin America, protection of the privacy and confidentiality of persons has been seen as the administrative responsibility of the informatics authorities only in Ecuador and Venezuela.68/

64/ Shawn Tully, "Princeton's rich commodity scholars", Fortune, 9 February 1981.

65/ María Elena Hurtado, "Tug of war over computers", South, January 1982.

66/ On this subject, see the interview with the head of the Special Department of Data Processing of Brazil in Jornal do Brasil, 1 November 1981.

67/ María Elena Hurtado, op. cit.

68/ Based on information from the Department of Informatics of Argentina.

There are various angles to this problem. The first is that a number of items of diffused information about an individual might become very sensitive if co-ordinated by a central data processor, in cases such as job seeking, purchase of insurance, access to loans or institutions, etc.69/ A second level of problems originates in the difficulty of correcting errors or possible obsolete facts in information which is totally reserved, or at least to which common citizens have difficulty in gaining access. Moreover the control of the information incorporated into information processing systems is usually difficult and/or costly.

A third type of problem is related to the possibility of misuse of the information, both by those who control the computers and data banks 70/ and by persons outside the system but with a knowledge of computer science. "Computer crime" is systematically increasing throughout the world.71/

12. A cross section: the colour television receiver industry in Argentina

The comparison between the Argentine industry producing black and white television receivers (hereafter called BWTV) in 1974 and the colour television set industry (hereafter called CTV) in 1980 is significant because it shows the multiple impact which may be produced by the transformation of a sector of the electronics complex and its importance in public policies. In addition, in the Argentine electronics industry -one of the three largest in terms of volume in Latin America- BWTV represented 36% of the value of production of equipment in 1974,72/ and CTV 45% in 1980.73/

In 1974, BWTV was mainly composed of a dozen terminal enterprises, almost all using local capital. Ninety per cent (in monetary terms) of its parts and components were of domestic origin, thus generating jobs in the supplier industry in an almost

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69/ Arthur J. Cordell, The content and control of future traffic patterns in telecommunications, Ministry of Transport and Communications, Ontario, 1981.

70/ Hideo Myyashita, "The information society: what will it bring?", Journal of Japanese Trade and Industry, No. 2, 1982.

71/ Charles L. Howe, "Coping with computer criminals", Datamation, January 198?

72/ Based on INTI and BMFT, op. cit.

73/ E. Cohen, A. Godel and H. Nochteff, Estado de la industria electrónica argentina, estimación preliminar de valores en 1980. Informe a Grupos de Trabajo de Régimen Sectorial (unpublished).

equal amount to that of the terminals.74/ Eighty per cent of BWTV technology was domestic.

In view of the importance of BWTV in the electronics equipment industry, the above situation contributed decisively to its being considered as mainly based on domestic technology.75/ The main weakness of BWTV was the need for a highly protective tariff, common to almost the entire Argentine manufacturing sector.

Since the early 1970s, and with greater intensity since 1975-1976, the decision to establish colour TV transmission service began to be discussed. During this decade, technological changes occurred in the world television industry which reduced the number of parts in a colour television set by half.76/

In view of these changes, the BWTV firms asked the Government to introduce CTV (both in regard to time-span and public policies) in such a way that it would have a positive effect on the development of the electronics complex of the country.77/

The traditional production of electronic consumer goods declined sharply in Argentina after 1975, and by 1979 it had almost disappeared. This occurred for various reasons, such as the technological changes which resulted from the growing incorporation of integrated circuits into the electronics complex, and, at the national level, the accelerated opening to imports after 1976-1977. In this context, CTV -whose transmissions were to begin at the end of 1979- appeared as the only sectoral alternative for the survival of both the terminals and the supplier industry.

To make this possible, it was first necessary that the terminals should know beforehand the tariff duties both for finished goods and components, in order to improve the development of the equipment and estimate the prices of the components, which are necessary data for making technological decisions on the equipment; and secondly, in addition to establishing tariff protection for the equipment, the relative price of the assembled and fitted subsets had to be raised in the same way.

74/ See H. Nochteff (Co-ordinator and rapporteur), "Conclusiones del Grupo de Trabajo TV color", in La industria de las telecomunicaciones. Su presente y futuro. Comando de Institutos Militares, Escuela Superior Técnica General Manuel N. Savio, Buenos Aires, 1981.

75/ According to UNCTAD, Electronics in developing countries: issues in transfer and development of technology, 1978.

76/ UNIDO secretariat, Implications of microelectronics for developing countries: A preliminary overview of issues, UNIDO, 1981, p. 6.

77/ UNCTAD, op. cit.

This latter point is of the greatest importance in defining the type of terminal enterprises with competitive advantages, the possibilities for the supply industry, and the technology to be used. Basically, a terminal which is not vertically integrated may assemble equipment by using one of three systems of component and part supply, as follows:

(i) purchase of components and parts from various domestic or foreign suppliers;

(ii) purchase of all the components and parts separately, but from a single supplier, known as the Completely Knocked Down System or CKD;

(iii) purchase of all the components and parts from a single supplier, but already assembled and fitted in a very small number of subsets, known as the Semi-Knocked Down System, or SKD.

The difference between the first alternative and the others is very clear. In the first case, the design and a large part of the technology are determined by the terminal, which must have technological capacity and quality control. It thus maintains its commercial and technological independence.

In the second alternative, the design and technology are those of the supplier and commercial independence is lost. However, there continues to be a need -although to a lesser extent- for engineering capacity and quality control for the assembly process. The price of some individual components may be negotiated -although on very unfavourable terms- for those who can find alternative sources or even develop suppliers.

In the third (SKD), the technology is not only determined by the supplier but is only known by the latter, and no engineering capacity is required nor can alternative sources be sought, since the subsets are exclusive to the models being assembled. The process of purchase and assembly is drastically simplified. The effects are total technological and commercial dependence, reduction in employment and practical elimination of skilled and professional labour.

The import duties for equipment and parts were made known only a few months before the beginning of the colour transmissions, and import duties were not applied for the SKD supplies, which are easily identifiable. Added to the liberal attitude towards imports (it is calculated that 250 000 receivers wer introduced in 1980 as accompanied baggage alone: a volume equivalent to almost 8 months of local production in the same year), this meant that it was decidedly advantageous

to seek to conclude SKD supply agreements with companies abroad, since the time available did not allow for timely access to the market if alternatives which involved greater domestic development were chosen.

In summary, the instant appearance of changes which occurred in this sector of the electronics complex during the 1970s (as shown by the fact that the demand for receivers began, practically speaking, with the initiation of the transmission service), in the absence of a technological and industrial policy which took them into account, produced the effects which may be seen in table 1 and which are summarized below:

(i) reduction by 34% in employment in the terminals, even with an increase in production (in terms of value of components, each CTV receiver is equivalent to approximately 3 BWTV receivers, so that 380 000 CTV are equivalent to approximately 1 140 000 BW receivers, or more than double the BW production of 1974);

(ii) reduction by 88% in employment in the domestic supplier industry;

(iii) reduction by 78% in the production of the domestic supply industry, not counting their own suppliers;

(iv) increase by 767% in the import of components and parts;

(v) change of origin of the technology: from 80% domestic to 80% foreign.

Given the importance of the sector, this decisively contributed to the substantial change in the share of domestic technology in the electronics complex in Argentina.

Although it has not yet been verified, the above information on the profile of skills required by SKD production leads to the conclusion that a sharp drop has occurred in skills and consequently -ceteris paribus- in the real wages of the employed labour force.

Table 1

THE TELEVISION RECEIVER INDUSTRY IN ARGENTINA a/

Comparison between the BWTV industry in 1974 and that of CTV in 1980	1974 BWTV	1980 CTV	Variation %
1. Value of production (thousands of current US$)	333 830	415 000	
2. Production (units)	550 000	380 000	
3. Personnel employed in the production of the terminal enterprises	5 600	3 700	-34
4. Demand for domestic parts and components (value of local production of parts and components by the TV industry), thousands of current US$	electr. 73 000 others 45 000 total 118 000	26 000	-78
5. Personnel employed in the domestic parts and components supplier industry	electr. 3 400 others 2 100 total 5 500	650	-88
6. Import value of parts and components for TV - thousands of current US$ CIF	16 000	138 000	767
7. Total import value of TV parts and components, in relation to value of total imports of parts and components, for the electronics industry (%)	28	57	104
8. Percentage of the value of terminal production accounted for by foreign technology	20	80	300

Sources: This table has been drawn up by using data from:
- CADIE, Primer Simposio de la Industria Electrónica Argentina, Buenos Aires, 1977, especially for 1, 2, 3, 4 and 5 in 1974;
- CADIE, Comercio Exterior Argentino de Productos Electrónicos, Buenos Aires, 1979, for 6 and 7 in 1974.
- E. Cohen, A. Godel and H. Nochteff Estado de la industria electrónica argentina, estimación preliminar de valores principales en 1980 (unpublished), parts 1, 2, 6 and 7 in 1980.
  mates for 8 and 3, 4 and 5 in 1980.

a/ The ons which may be drawn relating to values of production in current dol 1 and 4) with each other or with other values (personnel, imports, et ; into account that between 1974 and 1980 (annual averages), the pric nited States dollar in terms of current Argentine pesos rose by a factor .5 while the industrial wholesale price index (index of total non-agricultural wholesale prices of the Statistics and Census Institute) rose by a factor of 88.7.

III. POSSIBILITIES FOR ACTION

Decisions pertaining to the electronics complex have a variety of effects that influence the dynamism of long-term national development, in view of the characteristics of microelectronics technology and its pervasiveness. The options available in this respect are broad in scope and strategic in nature. In this chapter, some possible options will be discussed; these are not intended to replace the analysis that must be made of the particular situation of each country, but are put forth to stress certain elements considered basic to such analyses.

1. The general framework: selective endogenization

Any course of action taken by the Latin American countries with regard to microelectronics should be aimed at changing the present situation where the incorporation of this technology is exogenous. The objective should be to reverse the passive and indiscriminate trend in the process and to redirect it towards the goal of meeting the needs of the region. Microelectronics could thus become an endogenous, development-inducing factor.

This endogenization should be selective, because of the diversity of local situations and national objectives and of the differences in availability of resources and the impossibility of achieving simultaneous development in all aspects of this technology. Within certain limits, the countries do have a choice; in fact, they always make a choice, inasmuch as public policies may consist of either action or omission.78/ It is a matter of identifying alternatives and deciding on a course of action. The courses followed by the developed countries to encourage the growth of the electronics complex are different from those that might be followed by the developing countries, which still have to be set.

2. Criteria for setting priorities

The criteria for setting priorities should be focussed on the gap between the technological potential of the integrated circuits offered on the world market and the range of existing applications. The fundamental objectives would be to develop applications of the available microelectronics, producing adequate software to solve national problems of data processing.

78/ On the concept of public policies, see Eugenio Lahera, "Evaluación instrumental de las políticas públicas", Revista de Administración Pública, Facultad de Economía y Administración de la Universidad de Chile, No. 6, 1981.

The type of applications whose development should be given priority will depend on an assessment of the problems in the solution of which microelectronics might be useful. In very general terms, some important objectives may include the following:

(i) the development of applications in those sectors of the economy where existing comparative advantages may be reinforced or problems having priority for social reasons may be solved;

(ii) the development of applications which make better use of the comparative advantages existing within the electronics complex itself or of the support provided by national strategies that have already produced some consolidation of a given sector of the electronics complex. With regard to the former, it seems clear that the option should be for products that require more highly qualified human resources, especially professional; in Argentina,79/ this would mean choosing certain branches of medical electronics 80/ or of measurement and control instruments.81/ In the latter use, the choice for Brazil would be in the area of data processing, a sector of the electronics complex already given priority by the State.82/

(iii) the development of applications which involve getting closer to the base of the technology, i.e., integrated circuits.

There are, however, certain limitations to these possibilities based on the development of software:

(i) if efforts are concentrated on "utilization software", the possibility of changing the trend of applications, which is one of the central objectives of the proposed policy course, would be significantly narrowed:

(ii) the existence of firmware reduces the flexibility of application for anyone who has not advanced towards the stages of technology and production of

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79/ Hugo Nochteff, "Electrónica. Una industria cerebro intensiva". Competencia Buenos Aires, October 1976.

80/ Hugo Nochteff, "Electrónica. La industria electromédica argentina", in Medicina y Sociedad, Buenos Aires, 1979.

81/ Philip Maxwell, Consideraciones sobre las ventajas comparativas de la industria electrónica argentina, INTI, Buenos Aires, 1979 (unpublished).

82/ On trends in Brazilian data-processing policies and recent problems, see Wilvia Helena, A industria de computadores: Evolução das decisões governamentais, and Iván Da Costa Marques, "Computadores; parte de un caso amplio da sobrevivencia e da soberanía nacional", in Revista de Administraçao Pública, Fundaçao Getulio Vargas, Rio de Janeiro, October/December 1980.

integrated circuits on which software is designed and imprinted. However, this trend is not completely symmetrical within the electronics complex as a whole, but is concentrated on applications that require large series of circuits with the same basic software (custom integrated circuits). This is not a disadvantage for a great many of the applications that can be developed by the manufacturing or primary sectors of the region, which can be produced in low series. However, it does mean that technological forecasts must be kept up to date and an effort must be made to develop proper integrated circuit technology, an effort which has very little chance of being successful unless it is carried out as part of a regional programme.83/

Once it has been decided which sectors should be given priority in the introduction of microelectronics, the need for simultaneous action with regard to other parts of the electronics complex that serve as support sectors should be considered. The reason is that a strategy that concentrates on software must ignore neither the development of electronics hardware nor the limitations of industrial development (the engineering industry, final stages of the plastics industry, etc.). Otherwise, there would be a tendency to limit utilization of software or to produce intelligence for transfer abroad under extremely disadvantageous conditions.

3. The role of the State

(a) Differences between the role of the State in the leading countries and in the Latin American countries

In most countries that are leaders in microelectronics,84/ public financing of research and development (R and D) amounts to more than 50% of the total costs. The participation of the State as an implementer of R and D projects is, however, much lower; this shows how important public financing is to private R and D. In the United States, for example, 51% is State-financed, but only 16% is implemented

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83/ Juan Rada, The impact of microelectronics and information technology with reference to Brazil, Argentina and Bolivia. UNESCO, 1980, p. 89.

84/ In 1980, the United States produced 64% of all integrated circuits in the group of market-economy countries, and Japan produced 25%; they were followed by the Federal Republic of Germany, France and Great Britain. Adding the rest of Western Europe, 99% of integrated circuits were produced in the market economy countries, according to the Nora Report, quoted in John Bessant, Microelectronics and Information Technology: An Overview of the European Experience, prepared for the First Latin American Seminar on Microelectronics and Development, Buenos Aires, 1981.

by the State.85/ In addition to providing support for R and D, the State plays an important role by planning its purchases to favour domestic industries.86/ In the United States, the State was also instrumental in the development of microelectronics. In the leading countries, State action in connexion with the electronics complex includes specific policies by project and sector, long-term strategic planning or implementation, the use of co-ordination institutions, the maintenance of close ties between industry and government, support through direct aid and purchases, and promotional measures.87/

Although there are no quantitative estimates for assessing State support for the domestic development of electronics in Latin America, the information available shows that there is a marked contrast between the approaches of the leading countries and those of the region.

The United States "Buy American" Act, for example, provides that in government purchasing United States products must be given a degree of preference equivalent to twice the margin of preference granted in Argentina; this surely is not in proportion with the protection needs of the electronics industries in the two countries, in view of the differences in size and development.88/ Although the countries of the region have public agencies with direct or indirect responsibilities in the development of the electronics complex, they all suffer from shortcomings as regards financing, articulation with the private sector,and other agencies in the country, access to the higher levels of Government, or capacity for influencing economic policies, or they have various of these problems at once.89/

85/ The percentages refer to total R and D and are estimated to be equal or higher in the case of the microelectronics industry. In 1975, the five leading countries accounted for 60% of total R and D expenditure in the world; see Fabio S. Erber, "Desenvolvimento Tecnológico e Intervenção do Estado: um confronto entre a experiencia Brasileira e a dos países capitalistas centrais", Revista de Administraçao Pública, Fundaçao Getulio Vargas, Rio de Janeiro, 1980.

86/ The Japanese telephone administration (NTT) reserved 100% of the market for Japanese enterprises up to 1980, when Nippon Electric was already second in production of telephone equipment worldwide. See Business Week, December 1980, and John Bessant, op.cit.

87/ John Bessant, op.cit.

88/ Based on Fabio S. Erber, op.cit., and analysis of Decree 5340/63 and Act 18875 of Argentina.

89/ See Pradeep Bhargava, Report of the visit to Venezuela and Mexico under the UNDP Fellowship, Government of India, Department of Electronics, New Delhi, 1976 (mimeo) and Juan Rada, The impact of microelectronics and information technology with reference to Brazil, Argentina and Bolivia, UNESCO, October 1980 (mimeo).

The main exception is Brazil, because of the administrative level and responsibilities of the Special Secretariat for Data Processing and its influence on the country's computer industry, and because of the set of policies that have contributed to the rapid development of the electronics industry since the mid-1960.

The difference in the relative positions of Brazil and Argentina is due fundamentally to the differences between the public policies of the two countries. An example of this is the outcome of the Brazilian policy on data processing, as a result of which domestic production of video terminals substituted imports costing US$ 2 000 per unit with Brazilian-made products incorporating approximately US$ 100 FOB of imported components per unit.

(b) State purchases

It is difficult to exaggerate the effect of public purchases on the electronics complex: in 1975, purchases by the public administration represented over 40% of the global demand for electronics in the world.90/ Although there are no exact estimates for Latin America, the proportion is apparently higher.

State purchases affect the technology, the suppliers and the equipment of the private sector that uses public services. When there is an administrative decision in telecommunications to provide a new service, the purchasing policy will determine, on the one hand, the demand for and the technology of the central systems, and on the other, the ancillary equipment of users and its interface with the public system, which must be compatible. For these reasons, the State orients the technology in use towards that of the suppliers it chooses and grants them other competitive advantages on the domestic market, such as the prestige and the critical mass to compete in the private market.

In fact, it appears that this power -which in any event is already being exercised- is hardly ever used to further the development of the electronics complex in the region.

This is due to a large extent to the lack of departments specialized in technology that could expand the range of technological options open to public enterprises and agencies. This means that as they do not have the technical capability to "untie packages" they tend to resort to "turnkey" purchasing: a practice which, for well-known reasons, reinforces the exogenous nature of the

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90/ OECD, Interfutures, Final Report, Paris, 1979, table 53.

incorporation process. It should also be pointed out that as the primary consideration of public service enterprises is the provision of service and the cost of the equipment needed for this, they fail to consider purchases that could stimulate the local development of the electronics complex.

The above considerations should be taken into account in any policy aimed at developing the electronics complex in the region.

Current administrative structures hinder the process of selective endogenization because among other reasons, of the aforementioned tendency to make turnkey purchases and to reduce technological decisions to a minimum.91/ In order to establish strong interaction between the public and the private sectors, of the type that exists in the leading countries, public agencies and enterprises should be articulated with domestic private firms, as well as with technological institutes and universities. A co-ordination and planning agency in which the private sector would be represented should also be created for this purpose.

In Brazil, a move in that direction was the creation of the Núcleos de Articulação com a Industria (NAI), -113 of which were created in 1978- which were overseen by a co-ordination commission. It appears, however, that the objectives were only partially fulfilled because there was no policy to favour domestic enterprise and because the NAI were often quite removed from the decision-making centres of the State enterprises.92/ This shows that the development of the electronics complex calls for an integrated and well-co-ordinated approach supported by an institutional system that will facilitate it.

Another example of action in this field is the "Compre Argentino" and "Compre Nacional" system.93/ Although its purchasing policy has many positive features (untying of packages, design and planning based on domestic supply, preferential pricing regulations for local equipment, etc.), however, it has not had a significant impact on the development of the electronics complex in Argentina.

Because of the aforementioned indirect effects, the public sector, in setting its purchasing policy, must consider not only its impact on local development of the electronics complex, but also the extent to which imports are necessary.

91/ See A. Araoz, J.A. Sábato and O. Wortman, Compras de tecnología en el sector público: el problema del riesgo, Buenos Aires, July 1974; and J.A. Sábato, El rol de las empresas públicas en el desarrollo científico-tecnológico, CACTAL, OAS, Washington D.C., 1972.

92/ Fabio S. Erber, op.cit.

93/ Based on Decree 5340/63 and Act 18875 of Argentina.

(c) Technically regulated markets

Certain markets are directly influenced by the State even when the public sector is not a significant buyer. In telecommunication services not provided by the State, for example, the State nevertheless usually establishes service standards and technical specifications for the equipment marketed. This is done because of the need to rationalize the radioelectric spectrum and because of other considerations of national defence and user protection.

This intervention has an influence on what technologies are adopted and the possibilities for local development; thus it can be used to rationalize the incorporation of technology and to try to ensure that the technology chosen is the best suited to the needs and possibilities of users. It should be borne in mind that this intervention takes place in regard to equipment and systems for which there is a considerable development potential in the region 94/ and in respect of which there is a greater need for readjusting the supply generated in the developed countries (rural areas, small towns). In addition to telecommunications, this applies to the market for health and educational equipment, where the problems and possibilities are similar.

(d) Protection and promotion in electronics

The mechanisms for protecting and promoting industry with a view to furthering the local development of the electronics complex are no different in principle from those that may be used for other priority economic activities. Rather than proposing protection and promotion systems, therefore, some general comments will be made on the characteristics of such mechanisms.

In the first place, the use of international prices as a parameter for measuring the "efficiency" of regional production is highly questionable, because public financing of R and D costs, risk-reducing policies and the "trade war" between developed countries detract from the usefulness of international prices as market signals.95/ Moreover, the intensity of R and d in the sector and the use of strategies oriented towards the development of software make it necessary to develop mechanisms capable of measuring and protecting or promoting technological

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94/ See J. Mauro and H. Nochteff, Informe sobre el sector de radiocomunicaciones, Buenos Aires, 1980 (mimeographed).

95/ See I. Mackintosh, "Micros- the coming word war", in T. Forrester (ed.), The microelectronics revolution, Basil Blackwell, Oxford, 1980.

value added: a problem often faced by Latin American countries. The evaluation of the technological effect of each subprocess is a valid but inadequate means of making an estimate. Its usefulness as regards equipment may be seen in the differentiation between forms of production based on SKD and CKD supply (see chapter II), which some Latin American countries have begun to take into account.

(e) Interrelation between domestic private enterprises and major users

The major electronics enterprises are almost all TNCs (especially in the areas of telephone equipment, computers, office machines and semiconductors). Local participation is concentrated in medium-sized and small enterprises. In some cases, these small enterprises are innovative and technology-intensive (e.g., in electro-medical equipment and instruments in Argentina and in microcomputers in Brazil), but even in these cases they are seriously hampered by financial and commercial constraints.

If the purchasing policies of the public sector are to play the motivating role they play in the leading countries, the need to modify relations with suppliers must be taken into account. In the case of local enterprises, the change should be aimed at establishing closer relations and increasing the capacity for direct dealings with small and medium-sized firms.

The effect of this on the development of domestic enterprises may be decisive, because it provides a critical mass with which to undertake technological development and compete on the private market; it produces a demonstration effect through public purchasing; and it generates interaction in seeking technological options different from those offered by the TNCs. At the same time, any encouragement given to these domestic enterprises will substantially improve their ability to supply the major private users.

4. Training and technological information

(a) Transfer and identification of technology

The transfer of technology is a very important channel both for training and for technological information, but only if the technology really is transferred, in other words, if the country that pays for it is able to master both the substantive and the operational aspects of the technology. What is often referred to as transfer of technology may be quite different: it may consist of payments between TNC subsidiaries and the parent company or payments for franchises for

the marketing of a certain good. It is difficult to justify the first type of pay ut, inasmuch as the firm has already amortized the technology in question; in this regard, it should be borne in mind that the legislation of several Latin American countries does not allow such transactions. As for the second category, such arrangement should only be authorized with good cause.

Depending on the type of technology that is wanted, the transfer may take place all at once or it may require the establishment of a continuous mutual relationship that is advantageous to both parties. Special care must be taken when technology is incorporated into equipment, since this usually initiates increasingly costly chains of technological determination. In such cases the relationship would be continuous, but it would be increasingly burdensome for the recipient. This will probably be the case with the new telephone plants being installed in the major countries of the region.

One specific form of search for technology is the so-called "technological intelligence".96/ In the case of microelectronics, this is a particularly suitable means because technology is commercially available and because it can be utilized on the basis of the software capacity developed in the countries of the region. Concretely, there are in the developed countries academic and research institutions that provide technological services in the area. There are also small consultant enterprises staffed by former members of the semiconductor industry, who provide technological and market information commercially. There is also the possibility of purchasing it directly from technology-intensive small and medium-sized enterprises.

In order to achieve success, the negotiating capacity of the enterprises of the region must be increased through economic and technological support from governments as well as through international co-operation.

(b) Technology centres and enterprises

In many cases, the technology centres of the region do not have enough contact with the major users of electronics and local producers. This is largely due to the fact that the exogenous nature of the incorporation process leads to

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96/ This discussion is based mainly on the presentation by Ward Morehouse, The Third World in Silicon Valley, at the First Latin American Seminar on the Socio-economic Impact of Microelectronics Technology, Buenos Aires, 9-11 December 1981.

a very limited demand for local technology. This does not encourage co-ordination of the efforts of these centres, since demand is not concentrated enough to influence trends in the supply of technology. One of the fundamental ways to reverse the process is to concentrate efforts on the creation of technological centres in the major public users and in the agencies that take decisions on issues directly related to priority areas of the electronics complex, such as centres concerned with technical regulation in data processing, communications, education or health, and those concerned with industrial policies in electronics.

In order to be effective, these centres must have decision-making power or must be closely linked with decision makers. They must also have formal relations with the private sector, so that their interaction with the potential local supply will be a central function and not a residual one.

These centres will have only an indirect influence on the incorporation of technology into the private sector, which makes it essential to have an information policy on production technology in order to improve utilization of the potential of the electronics complex in the private sector, accelerate incorporation, improve utilization and, in certain cases, steer demand towards local industry.

It should be borne in mind that if an adequate supply of information is crucial in the application of the electronics complex in the developed countries, it will be even more so in the region, particularly in the enormous segment of small and medium-sized local enterprises.

The development of technological consultant enterprises would make it possible to advise enterprises on what technologies are most suitable, inform them about opportunities for incorporation they had not considered, put them in touch with potential local suppliers, and contribute to the development of the device or system involved.

Support for the formation and financing of technological enterprises should be co-ordinated with expansion of public centres (including those in universities) and with industrial promotion policies, especially those concerning small and medium-sized local enterprises.97/

97/ See E. Ballerini, Empresas y Cooperación, IV Simposio Latinoamericano de la Pequeña y Mediana Empresa, October 1980, Buenos Aires.

(c) Reversing the brain drain

The brain drain associated with the electronics complex is particularly heavy, because of: (i) the growing disparity between the development of the electronics complex in the developed countries and in the countries of the region; (ii) the relative scarcity of software in the developed countries, which enhances the appeal of migration;98/ and (iii) the rising expectations for electronics-related careers, which tend to increase enrolment in universities and technical institutions beyond the demand generated by domestic development in electronics. In the case of Argentina, it is estimated that approximately 25% of the electronics professionals who graduated since 1950 have emigrated.99/

Reversing this flow may be one way of incorporating technology, since it may be assumed from available data that a large part of the professionals who have emigrated are now working in R and D, either in industry or in the academic institutions of the developed countries.

5. The role of the transnational corporations

The important role played by the TNCs in generating, producing and supplying microelectronics has already been pointed out. The practice of assigning to different countries the role of producer, exporter or mere consumer of microelectronics is often decisive, especially in the absence of national policies in this regard. The concentration of research efforts in the developed countries (92% in 1977) means inevitably that the developing countries will play only a minor role in this regard; the participation of Latin America, for example, is only 1%.100/

The TNCs should adjust to national policies and local development objectives and priorities and should make a positive contribution to their achievement and to the creation of a scientific and technological capacity in the recipient countries.101/

To this end, the countries must define their objectives and priorities, stating explicitly what the specific contribution of the TNCs is to be. Once the

98/ Hugo Nochteff, El efecto Mateo; Informe Industrial, Buenos Aires, 1981.

99/ Estimated on the basis of data from A. Dmitruk, E. Elisetche, A. Godel and N. Prieto, Recursos humanos en electrónica, paper presented at the Congress of the National Electronics Programme, Buenos Aires, September 1981.

100/ U.S. Department of Commerce, U.S. Direct Investment, 1981.

101/ CEPAL, Regional Programme of Action, 1981.

role of the enterprises is defined, their co-operation may be actively sought, both among firms already in the country and others of different sizes and origins.

Negotiating with TNCs is usually complicated and is not necessarily easy; however, there are important points on which the optimization of profits by the corporation and the fulfilment of national objectives coincide. The establishment of clear priorities and rules of the game facilitates understanding with these firms.

It is very important to centralize the national negotiating position, as this saves time and misunderstandings. The different problems involved in negotiating with the TNCs should, as far as possible, be dealt with and solved simultaneously.

6. International co-operation

Microelectronics is a particularly suitable field for international co-operation among countries and institutions of the Third World in general and of Latin America in particular. The similarity of the problems and requirements of the different groups of countries, as well as the need to achieve minimum scales and the necessary critical masses should encourage such co-operation, as regards both the development and the incorporation of microelectronics technology.

National policies should encourage international co-operation among the Latin American countries and other developing areas in this regard. They should also promote exchanges of information, the development of pilot programmes and the signing of technology agreements with developed countries.

The transfer of technology and know-how between countries having different levels of development in electronics should be systematically explored and consideration should be given to the possibility of joint development work in connexion with specific problems of the countries concerned. Emphasis has also been placed on the desirability that the developing countries should create or strengthen regional centres that will enable them to participate in scientific progress, attain their own technological level and negotiate the transfer of appropriate technology on suitable terms.102/

102/ UNIDO, United Nations Conference on Science and Technology for Development.

A common policy with regard to TNCs could be introduced gradually in order to achieve minimum objectives in this regard. To this end, the Latin American countries should reach some degree of consensus on a more general strategy for development of the electronics complex.

The search for technology abroad may be facilitated by joint action on the part of several countries as well as by the exchange of experience gained in the process. This would be supported by the negotiating power represented by the demand for goods from the electronics complex in the region. Some indicators of this demand are the volume of imports and the telecommunications market, which amounted to over US$ 3 000 million in 1980, taking into account only Argentina, Brazil, Mexico and Venezuela.

Not only the governments of the region, but also the various groups of producers, universities and general research associations, supported by international agencies, must play a significant role in the creation and implementation of these and other initiatives.