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Microelectronics and Latin American development

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According to OECD, the electronics complex will be the main pole around which the production structures of the industrial societies will be reorganized in the next quarter of a century. The dynamism of this complex in such societies, its impact on trends in investment and international trade, and the growing incorporation of its products and technologies in the Latin American countries are influencing to different extents and in different ways the national economies of the region. Among the potential repercussions of the electronics complex on Latin America, special mention may be made of increases in the differences of productivity with respect to the developed countries; changes in the comparative advantages of the various economies, in employment, and in ways of public administration; growing asymmetry in international information flows; and the threat to personal privacy and security, *inter alia*.

In view of the foregoing, the authors maintain that the action of the Latin American countries with respect to microelectronics should be aimed at overcoming the exogenous nature of the present form of incorporation of such technology. Efforts should be made to reverse the passivity and lack of discrimination which currently characterize this process, orienting it instead towards the satisfaction of the region's needs. In this way, microelectronics could become an endogenous factor generating development which would permit these countries to progress more rapidly towards their goals. This endogenization should be selective, both because of the diversity of national situations and goals and because of the disparity of resources and the impossibility of achieving simultaneous development in all aspects of such technology.

The priorities determined, for their part, will depend on the appraisal made of the problems which microelectronics can help to solve, such as the solution of priority social problems or the application of these technologies in sectors of the economy where there are 'bottlenecks' or where they can strengthen existing comparative advantages.

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Introduction

During the last decade, people have begun to talk of a new industrial revolution, brought about by the widespread application of electronics, which is the industry with the highest growth rate in the world since 1945 and whose innovations have spread to the other industries and the main services. The impact of electronics is based mainly on the development of microelectronics technology, but also on other technologies closely linked to it.[1] These technological advances, together with the sectors of industry which manufacture the products and the highly specialized human resources required by this activity, constitute what has been called the electronics complex, regarding which the OECD has said that it will become the main pole around which the production structures of the advanced industrial societies will be reorganized during the next quarter of a century.[2] The effects of the incorporation of microelectronics may extend from the improvement of a product (automobiles) to the radical transformation of its composition, cost and performance (computers) or even the creation of totally new products (word processors). In some cases there has not only been a transformation in the composition of the product, but also in the industry producing it at the world level, as has happened with watches.[3]

These transformations take place through changes in the products and in the capital goods with which they are made. Great progress has been made in the replacement of parts and mechanisms, and integrated circuits have replaced many of the functions of springs, levers, stepping motors and gear assemblies.[4]

The replacement of components and mechanisms makes possible a significant

[1] Examples of this are lasers, fibre optics, print-out and display technologies, etc. See D.H. Roberts, "Microelectronics and its applications", in *GEC Journal of Science and Technology*, vol. 46, No. 3, 1980.

[2] OECD, *Interfutures*, Paris, 1979.

[3] Juan Rada, *The impact of microelectronics*, ILO, Geneva, 1980.

[4] S. MacDonald, D. Callingbridge and E. Braun, "The case of semiconductors", in *Bulletin of Science and Technology Society*, vol. 1, Pergamon Press, U.S.A., 1981.

reduction in the number of parts in a product, with multiple effects on direct and indirect costs, the size of the plant, the amount of energy used and the reliability of the products themselves. The miniaturization deriving from this process makes it possible to introduce new functions and/or increase the spread of existing products. There is an ever-increasing degree of differentiation in such traditional products as automobiles, television sets and telephones. All this affects the production process in different ways, as less skilled labour is needed, there is a drastic reduction in the number of specialized supplier enterprises, and there is a lessening of the capacity of the terminal producer to "untie the technological package". This latter feature is due to the fact that for the terminal an integrated circuit is a 'black box' which takes the place of dozens and sometimes hundreds of parts involving more traditional technology. On the other hand, information on the characteristics of existing integrated circuits and their applications and on the ways of making proper use of them is increasingly important. The penetration of microelectronics in capital goods is having considerable repercussions on the manufacturing process: integrated circuits are now being applied in such tasks as the controlled movement of material and products; the control of process variables such as temperature, humidity and pressure; the cutting, shaping, mixing and moulding of materials; the assembly of components and subassemblies; quality control, and the organization of the production process.[5]

Generally speaking, the effects are similar to those already referred to regarding changes in products and those associated with increases in the level of automation. At all events, mention may be made of some more specific effects, such as the reduction of design time and of the lag in feedback between design, production, quality control and management; often, a simultaneous increase in the productivity of capital and of labour; and the introduction of greater flexibility in the capital goods through the growing incorporation of 'intelligence'.

One of the central features of the electronics complex is that it is bringing about a complete change in the automation of office work, which was until now unaffected by earlier technologies; this is due not only to the availability of office machines (including computers) with growing capacity to store, process and distribute information, but also to the no less important reduction in the cost and size of the equipment.[6]

The close relationship which exists between telecommunications and informatics has a number of effects which are so important and varied that this subject has taken up a considerable proportion of the publications in the field. In the present article, consideration will be given to only a few of these effects, such as the growing international flow of services and the tendency towards their concentration in the most highly developed countries; the possibilities opened up by the new technologies to countries with large rural sectors, especially as regards education and information; and the growing availability of cheaper, quicker and more detailed data on weather conditions, harvests, monetary flows, international prices, etc. Although these facilities could in theory be enjoyed by all the countries of the region, the evidence shows that so far they have been used to a much greater extent by the developed countries and the transnational corporations.

A feature of the electronics complex whose effects and potential with regard to development have not been sufficiently appraised is that the main motive force behind the advances in microelectronics was originally —and continues to be to a large extent— the demand of the military and aerospace sectors and the big corporations linked directly or indirectly to these. This creates a gulf between the technical possibilities of integrated circuits and the actual

[5] J. Bessant, E. Braun and R. Moseley, "Microelectronics in manufacturing industry: The rate of diffusion", in Tom Forrester (ed.), *The Microelectronics Revolution*, Basil Blackwell, Oxford, 1980.

[6] Juan Rada, *op. cit.* This reduction was from a weight of 2 542 to 0.30 kilogrammes and from a cost of US$ 200 000 to US$ 300 in 23 years, for almost equal performance, as between the IBM 650 and TI-59 calculators.

applications of them in other activities. This gulf even today continues to be large, and its main significance is that a lag in microelectronics does not necessarily mean an equivalent lag in their applications, which, in many cases of interest to the region, call for much smaller investments than those of the microelectronics industry proper.

From the point of view of public policies, it should be emphasized that the large number of sectors affected by the electronics complex, the importance of its effects, and the complexity of the intersectoral relations created tend to make it increasingly difficult to evaluate the costs and benefits of investment. Consequently, this calls for ever-increasing availability of technological information, continual planning work, consideration of the indirect and long-term effects of economic policy decisions and, finally, close coordination of public policies. These problems and needs are repeated in private business management, thus giving important advantages to transnational corporations producing goods and services, wich can only be made up for by suitable public policies.

I
The regional situation

(a) *The Latin American point of view*

The dynamism of the electronics complex in the developed countries, its impact on trends in investment and international trade, and the growing incorporation of its products and technologies in the Latin American countries are influencing the national economies of the region to different degrees and in different ways.

Most of the publications on this matter refer to the countries of highly advanced industrialization, and it is rapidly discovered that their conclusions cannot simply be transferred mechanically to Latin American conditions. This fact, together with the diversity of national problems, indicates the need to make an effort of research and analysis in order to understand the regional situation.

(b) *The incorporation of microelectronics*

The incorporation of microelectronics and of the products and technologies connected with it has constituted and still constitutes a process which is heterogeneous, sporadic and disordered in the region.

Moreover, the form and extension of this process vary from country to country. While some have reached advanced positions among the developing countries, in others the capacity for the production of goods and the handling of technologies in the electronics complex is either incipient or almost non-existent. Equally significant are the differences as regards imports, exports, availability and consumption. The incorporation of microelectronics has had a markedly exogenous origin, in which a decisive role has been played by the transnational corporations.

In order to make up the total supply, Latin America's imports are accompanied by locally produced goods which incorporate much less microelectronics and in whose production the transnational corporations are generally of great importance and nearly always dominate the market. In the case of informatics in Mexico, for example, six such corporations control the market, and one of them, IBM, accounts for 55% of the total, followed by Honeywell with 15%.[7] In Chile, the seven main transnational corporations control almost 95% of the market, with IBM at the head, accounting for 25%.[8]

The public sector is the main customer for the products of the electronics complex in the region, this being explained by its decisive

[7] Ministry of Planning and the Budget, *Política informática gubernamental*, Mexico City, 1980.

[8] The Economist Intelligence Unit, *Quarterly Economic Review of Chile*, Third Quarter, London, 1980.

importance in telecommunications, by the fact that it is the biggest purchaser of data processing equipment (in Mexico, for example, over 50% of computer sales are made to the public sector),[9] and by the significance of military expenditure in most of the countries of the region.

The private sector, both national and foreign, is also of importance in the demand for electronic consumer durables and for capital goods in the industrial, financial and services sector.

The characteristics of the main suppliers and purchasers mean that in practice both are outside the market in the traditional sense and this determines the characteristics and dynamics of the relationship.

(c) *Differences in productivity*

The disparity between the developed countries and those of the region as regards the speed of incorporation of the innovations of the electronics complex and the capacity for the adaptation of these to the national economy may further increase the distance currently separating them as regards productivity. These distances are attributable to the increase in productivity through the application of capital goods which incorporate microelectronics in the manufacturing sector, but they are also —and perhaps even more so— due to the possibilities of spectacularly increasing productivity in the services sector and the global impact of the improvement of information processing and communications systems.

It is also necessary to take into account the consequences of the improvement and differentiation of existing products through the incorporation of devices based on microelectronics. The greater productivity of the factors and the differentiation of products may displace goods produced in the region from the market, with a consequent reduction in national income. These are some of the reasons most often brought forward in the developed countries for promoting the incorporation and development of the electronics complex in their economies.

(d) *Comparative advantages*

Microelectronics can have an important effect on comparative advantages by reducing those based on low cost of labour and accentuating those originating from higher scientific and technological development.[10] Examples of these are the increasingly intensive use of capital in industries and processes which up to now involved high labour density, or the decline in the share of wages in the cost of capital goods.[11]

This transformation already seems to have begun in some activities. As was to be expected, microelectronics itself has been the first to take full advantage of its own innovations: thus, the transfer of semiconductor encapsulation work from the more developed countries to those where labour is very cheap has been halted, and certain electronic assembly industries have returned to their countries of origin.

(e) *More or less employment?*

In publications on the repercussions of microelectronics, repeated mention has been made of the unemployment generated by this new labour-saving technology both in the developed and developing countries. The information on the Latin American countries, however, is only scanty and partial.

There can be no doubt about the unemployment-inducing effect of this technology in those cases where what is sought is to rationalize the production process or expand the volume of production. The

[9] See "Entering the microcomputer age", in *Latin American Weekly Report*, London, 20 November 1981.

[10] See for example, R. Kaplinsky, "Microelectronics and the Third World", in *Radical Science Journal*, 10, 37, 1980 and K. Hoffman and H. Rush, "Microelectronics, Industry and the Third World", *Futures*, August 1980.

[11] In telephone switchboards the share of wages in manufacturing costs drops from 40% to 20% when electronics is substituted for electromechanical technology, and in the case of lathes it drops from 30% to 17% when ordinary control equipment is replaced with numerical control devices. See S. Jacobsson, *Strategy Problems in the Production of Numerically Controlled Lathes in Argentina*, Buenos Aires, 1981 (unpublished).

automatic cabin welding machine installed by Ford in Brazil uses four operatives to do the work previously carried out by 60, and it is very probable that the same will occur on an even larger scale with the introduction of robots on the Volkswagen production line in 1984. It may be noted that this is an industry which has problems and is in the midst of a process of reorganization not only in Latin America but all over the world.

However, there are also sectors where the introduction of microelectronics could simultaneously raise productivity and employment, as for example, in small and medium-sized enterprises which could increase the demand for labour if they had a better supply of producer goods which are relatively cheap, simple and easy to maintain and repair,[12] as already occurred with the introduction of electrical machinery. The same could be said of a considerable part of the informal sector, especially if suitable applications are developed, for example, for the improvement of hand tools.

The applications of microelectronics may have differing influences on the different levels of training of the labour force; generally speaking, it may be said that there will be changes in the qualifications demanded. The introduction of microelectronics technology brings about a polarization of employment between semi-skilled operatives and highly qualified technical staff, with a reduction of employment for skilled manual workers.[13] It is also claimed that it will bring about some lowering of the status of manual labour, which will become more repetitive and frustrating.

An important consideration when evaluating this problem is the economic growth that can be obtained by introducing microelectronics. This is because, in certain conditions of appropriation of the fruits of technical progress, the rapid growth of an economy can raise the standard of living of the population as a whole. Moreover, the displacement of labour must be evaluated within a broader context which takes account of the reduction in investment and material costs, the characteristics of scale involved, the greater flexibility, and the higher quality of the goods and services.[14]

(f) *The public sector*

Microelectronics offers solutions for a number of problems which arise at the different levels of public administration, especially as regards the massive processing of information on its different functions and the planning process. The introduction of microelectronics with this objective should be carried out in a carefully planned and rational manner, but in an alarmingly large number of cases this has not occurred. In the case of Mexico, for example, over 20 data processing firms installed over 340 different models of data processing machines –many of them mutually incompatible– up to the end of 1979.[15] The same situation is repeated, with some variations, in the other countries.

Modern data processing systems have not necessarily improved the services provided by public administration. In practice, they only speed up existing procedures, without getting rid of old bureaucratic practices. The costs of the data processing are frequently passed on to users, who also usually experience difficulties in correcting possible errors in the information fed into the systems. Moreover, there is an increasing possibility that such errors will occur, because of the tendency of administrations to place their confidence in the information already incorporated in the system.[16]

Nor has proper use been made of the enormous potential offered by microelectronics technology for planning processes, and indeed in some cases there has even been a

[12] G. Friederichs, *Microelectronics. A New Dimension of Technological Change and Automation*, 1979 (unpublished).

[13] ETUI, *The Impact of Microelectronics on Employment in Western Europe in the 1980s*, Brussels, 1980.

[14] Rafael Kaplinsky, *op. cit.*

[15] Ministry of Planning and the Budget, *Diagnóstico de la Informática en México*, Mexico City, 1980.

[16] Klaus Lenk, *Societal Implications of Information Technology*, International Social Science Council (undated).

deterioration in the level and quality of the information published. Economic and social information is tending to become of an increasingly private nature, so that differential opportunities for securing benefits through its use are being created.

Microelectronics technology is a fundamental part of modern military equipment. The marginal superiority of this equipment is frequently based on the incorporation of more advanced microelectronics, with high levels of technological obsolescence. This contributes to the expenditure by governments of large sums on the purchase of armaments and military equipment, the vast majority of which is imported from a few centres producing such goods.

Such imports increased between 1967 and 1976 from US$ 270 million to US$ 770 million (in 1975 dollars), thus bringing Latin America's share in the world total from 3.4% to 6% over the same period.[17] Even in those cases where progress has been made in the local production of armaments with electronic components, the latter are almost exclusively of external origin.

(g) *Misuse of the electronics complex*

The under-utilization of the goods and technology of the electronics complex is one of the main problems deriving from the conditions in which the latter tends to be incorporated in Latin America. The situation is even clearer in the case of informatics, since the existence of specialized centres in many countries of the region provides details which permit a fully documented appraisal of the problem.

Computers and related systems were introduced in Latin America as a result of impulses which may be considered to be exogenous. The suppliers of computers set themselves to conquer the market and pressured customers into buying products for which there was no local demand by claiming that they provided solutions for 'problems' which the salesmen themselves identified. This process[18] produced a very high level of demand compared with the real needs of the users and the objectives for which the systems were to be used; a marked gap between the equipment and the human resources required for it; and a heterogeneous collection of informatics equipment involving a number of models which was out of all proportion to the scale of use: thus, in one of the largest consumer countries in the region, 142 models were purchased for 230 public administration bodies, and most of these models were mutually incompatible.[19]

As a result of all this, the three biggest purchasers in the region (Argentina, Brazil and Mexico) found themselves faced with serious problems in making proper use of their equipment. On the one hand, there is a heavy degree of quantitative under-utilization, amounting in a considerable number of cases to 45/55% of the capacity,[20] as well as enormous maintenance difficulties. In the case of Mexico, it has been observed that the impossibility of independent maintenance brought about by the number of different models constitutes a serious limitation on the local informatics industry.[21] On the other hand, this had led to restrictions on the possibilities of finding new applications, especially those aimed at the "real needs of users and the possibilities of the community",[22] in spite of the three countries' potential for creating software.*

[17] U.S. Arms Control and Disarmament Agency, *World Military Expenditures and Arms Transfers, 1967-1976*, Washington, D.C., 1978.

[18] Department of Informatics, *Situación actual y tendencias futuras de la informática en el sector público*, Buenos Aires, 1982.

[19] Ministry of Planning and the Budget, *Política informática gubernamental*, Mexico City, 1979.

[20] See *Recursos computacionales brasileiros, Computadores instalados*, January/February 1981; Ministry of Planning and the Budget of Mexico, *op. cit.*, and also Department of Informatics of the Argentine Republic, *op. cit.*

[21] Ministry of Planning and the Budget of Mexico, *op. cit.*

[22] Department of Informatics of the Argentine Republic, *op. cit.*

* Originally, the term 'software' was applied to the instructions given to a computer to carry out certain tasks (such as complex mathematical calculations or payroll operations, etc.), while 'hardware' was the term used for a piece

The limited level of local software is perhaps the most negative consequence of the way in which the technology has been incorporated, not only because it frustrates the possibilities of adapting the systems for users, but also because software now represents close to 90% of the total cost of informatics systems at the world level.[23]

The advantages deriving from the incorporation of capital goods from the electronics complex or the incorporation of devices based on integrated circuits into existing capital goods are offset in the countries of the region by the rising cost of utilization of this equipment, including the cost of acquisition, installation, adaptation, training and maintenance.[24]

The lower the level of knowledge of the technologies and products connected with the electronics complex is, the greater this cost will be, so that it tends to be higher in the countries of the region than in the countries of origin of the technology, thus reducing the marginal effectiveness of its incorporation.

(h) *Transnational corporations*

The introduction of microelectronics into products and production processes may bring about significant changes in the international division of labour in the transnational corporations, which may in turn significantly affect the host countries.[25]

In the case of office machines, these corporations show a high degree of regional specialization expressed through international agreements on production and marketing and even through regional integration mechanisms such as the complementation agreements.[26] Thus, for example, in the early 1970s Olivetti specialized its installations in Argentina in the production of mechanical calculating and accounting machines, while it reserved typewriter production of its facilities in Brazil and Mexico. When the pressure exerted by microelectronics on the office machinery industry increased in the second half of the decade, the Olivetti Corporation reserved the production of new lines for its plant at Harrisburg (United States), while traditional production was transferred to the satellite plants, which were to supply the regional market under the integration schemes. By the end of the decade, the demand for mechanical office machines disappeared, and in 1980 the Olivetti Corporation decided to practically eliminate its facilities in Argentina, limiting them to the production of electronic calculators for the local market with only a small content of nationally produced parts; finally the plant ceased activities altogether in 1981. The number of staff employed had already gone down from 1 840 to 150 people.[27]

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of equipment or a set of items of equipment made up of electronics components, mechanical parts, etc. More recently, the meaning of software has been extended to include in general terms the entire technological activity needed to obtain a result from an integrated circuit or a set of integrated circuits, or even a system based on conventional equipment. In this article, the term software will be used in this broad sense and the term 'utilization software' will be used in the more restrictive sense. It should be noted that the limits between software and hardware are not rigid. In the case of certain integrated circuits (microprocessors), for example, the instructions are recorded physically.

Due to the rapid reduction in the cost of integrated circuits and the rise in the cost of producing software, efforts are being made to incorporate increasingly complex instructions in integrated circuits so as to mass produce them with the largest possible amount of software already physically included. This has led to the creation of the term 'firmware' to designate integrated circuits which incorporate more of the 'intelligence' provided by software.

[23] William Baker, *Analysis of microprocessors business*, National Semiconductor Company.

[24] This concept, together with its importance in the case of the electronics complex, have been defined in INTI and BMFT, *Estudio sobre el desarrollo de la industria electrónica argentina, Conclusiones, Fase 2*, Munich, 1981.

[25] Latin America's share of direct foreign investment went down 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, in contrast, the region's share increased from 18% to 19% between 1975 and 1979. Sources: *Survey of Current Business*, Ministry of the Economy of the Federal Republic of Germany, and Ministry of Economic Co-operation of Japan.

[26] Eugenio Lahera, "La división internacional del trabajo de las empresas transnacionales y los Convenios de Complementación de ALALC", in *Problemas del Desarrollo*, 39, Mexico City, 1978.

[27] 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 Socioeconomic Impact of Microelectronics Technology, UNESCO/FLACSO/Vienna Centre, Buenos Aires, 1981.

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

(i) *External trade in electronic products*

The quantitative effect of the spread of the electronics complex may raise problems for the region's external merchandise balance, as may be seen particularly clearly in the case of the trade in electronic products. Thus, on the one hand imports tend to grow rapidly: between 1974 and 1978, they rose from US$ 1 391 to US$ 2 172 million, which represents an increase of 52.2% in only four years. On the other hand, the trade balance shows a marked deficit: in 1977 the region's external trade in electronic goods came to US$ 2 139 million and the deficit was US$ 1 469 million or 69% of the total trade.

The quantitative results of the external trade vary widely, depending on the degree of electronic development of the countries, and especially their industrial and technological capacity, as may be seen from comparison of the aggregate data for Argentina, Brazil and Mexico with those for Latin America as a whole. In 1979, these three countries imported 92% of the integrated circuits purchased by the region,[28] which is a clear indication of their relative industrial and technological capacity. In 1977, the same three countries accounted for 96% of Latin American electronic exports, 57% of total trade, 50% of imports, but only 40% of the deficit.

The difference in impact according to the degree of capacity for making use of microelectronics is not only quantitative but also qualitative. The countries with the most capacity in this field of technology devote a much larger percentage of their imports to capital goods.

In 1979, the three countries in question accounted for 76% of imports of data processing equipment, 72% of imports of telecommunications transmitters and receivers, but only 44% of the main electronic consumer goods.[29]

(j) *International information flows*

There are various aspects in relation with which the outflow of information to the exterior may raise problems for the countries where it originates, and this may affect production and markets as well as financial transactions. The benefits of timely and systematically processed information –which constitutes a form of merchandise capable of producing profits– are generally enjoyed by the transnational corporations through their own information systems or by using other mechanisms.

The United States enterprise Penwait, for example, uses a system of data transmission by satellite to keep a permanent watch on the value of the currencies of the countries where it carries on activities in relation to the dollar, thus optimizing its profits with respect to fluctuations in such values. Another United States transnational corporation, ARMCO, uses the same type of information system so that it can buy or sell the foreign exchange required at the right time.[30]

There are between 100 and 150 of this kind of information networks.[31] Furthermore, in the financial sphere proper, in addition to the networks of the big banks, there is a Society for Worldwide Interbank Financial Telecommunications (SWIFT) of which only five Latin American countries, together with Singapore and Hong Kong, are members among the developing countries.[32]

From another point of view, mention

[28] Calculation based on data from United Nations, *Bulletin of Statistics on World Trade in Engineering Products, 1979*, New York, 1981.

[29] *Ibid.*

[30] Andrew Lloyd, "Précieux atouts pour les sociétés multinationales", in *Le Monde diplomatique*, Paris, December 1980.

[31] Jean Pierre Chamoux, "Monopoles nationaux et contraintes extérieures", *ibid.*

[32] Armand Mattelart, "L'informatique dans le Tiers-Monde", *Le Monde diplomatique*, April 1982.

may be made of the case of the United States Commodities Corporation, a futures marketing enterprise for such commodities as hog-fat and cattle, of which it may not hold any stocks itself: its main resources are the modelling and forecasting capacity 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 can only handle 4 800).[33]

Moreover, when the outflow of information is not subject to any restriction and this permits the indiscriminate use of telesoftware (the transmission of software through the use of telecommunication systems) the possibilities for the national development of software practically disappear.

(k) *Personal privacy and security*

There is great concern at the international level over the various ways in which microelectronics can affect personal security and the right of individuals to keep certain information confidential. The OECD, the Council of Europe and the European Economic Community, for example, have adopted agreements to protect privacy.[34] Within Latin America, the authorities in charge of informatics are responsible for safeguarding personal privacy and confidentiality only in Ecuador and Venezuela.[35]

There are various angles to this problem. The first is that social control may become exaggerated and be placed at the service of totalitarian régimes. Moreover, much information regarding individuals which is perfectly innocuous as long as it is dispersed may become prejudicial to them when it is correlated by a central information processing system, in such cases as looking for work, taking out insurance, access to loans or institutions, etc.[36]

Another type of problem arises from the difficulty which exists in correcting possible errors or instances of out of date information in the case of data which are completely confidential or to which ordinary citizens have difficulty in gaining access. Moreover, the control of information incorporated in data processing systems may be difficult and/or costly.

A fourth type of problem is connected with the possibility of misuse of the information, especially by those in charge of computers and data banks.[37]

II
Possibilities for action

(a) *The general framework: selective endogenization*

Whatever type of action the Latin American countries take with regard to microelectronics should be aimed at overcoming the exogenous nature of the present form of incorporation of such technology. It is necessary to overcome the passivity and lack of discrimination which currently characterize this process and to orient it towards the satisfaction of the region's needs. If this is done, microelectronics can become an endogenous factor which generates development.

This endogenization process must be selective, both because of the diversity of local situations and national objectives and because

[33] Shawn Tully, "Princeton's rich commodity scholars", in *Fortune*, 9 February 1981.

[34] María Elena Hurtado, "Tug of war over computers", *South*, January 1982.

[35] Based on information provided by the Department of Informatics of the Argentine Republic.

[36] Arthur J. Cordell, *The Content and Control of Future Traffic Patterns in Telecommunications*, Ontario Ministry of Transport and Communications, 1981.

[37] Hideo Myyashita, "The information society: what will it bring? ", *Journal of Japanese Trade and Industry*, No. 2, 1982.

of the disparity between the resources available and the impossibility of achieving simultaneous development in all aspects of this technology.

(b) *Criteria on priorities*

The focal point to be borne in mind when establishing criteria for priorities is the current disparity between the technological possibilities of the integrated circuits offered on the world market and the existing range of applications. A fundamental objective in this respect should be to identify more applications which can be carried out on the basis of available microelectronics, by producing the engineering skills needed to solve national problems.

This section will set forth some considerations on possible alternative forms of action. It does not, of course, pretend to take the place of the necessary analysis of particular national situations, but merely seeks to suggest the basic elements of such alternatives.

The priority given to particular applications will depend on the appraisal made of the problems which microelectronics can help to solve. In very general terms, however, mention may be made of some interesting objectives such as applications to particular sectors of the economy which will help to solve problems of high social priority or strengthen existing comparative advantages. These applications should seek to make better use of the existing conditions available within the electronics complex and back-up national strategies which have already brought about some degree of consolidation of a particular sector of it.[38] They should also give preference to those applications which involve a closer approach to the basis of this technology, that is to say, integrated circuits.

There are, however, certain limitations on these possibilities deriving from the development of product engineering and software. If the activities are concentrated on 'utilization software', for example, this significantly reduces the possibility of changing the orientation of their applications, which is one of the central objectives of the proposed approach. On the other hand, the introduction of firmware in integrated circuits reduces the flexibility of application for those who have not advanced to the stages of the technology and production of such circuits in which the software is designed and printed.

Once the sectors where the introduction of microelectronics is a matter of priority have been determined, it is necessary to consider also the possibility of taking simultaneous action on other parts of the electronics complex which serve as support sectors. This is because a strategy concentrating on engineering cannot leave out of the reckoning either the development of electronic hardware or the limitations inherent in the whole area of industrial development; otherwise, this would tend to "produce intelligence" for subsequent transfer to the exterior on extremely disadvantageous terms.

(c) *The role of the State*

In most of the countries which are leaders in microelectronics, public financing accounts for over 50% of the total amount spent on research and development.[39] The

[38] As an example of the first of these, it would seem desirable that Argentina should opt for the production of goods which require human resources of a high level of skill, especially professionals, by developing medical electronic goods or measuring and control equipment. As an example of the second approach, mention may be made of Brazil's decision to give priority to informatics as the sector of the electronics complex to be especially promoted by the State. See Hugo Nochteff, "Electrónica. Una industria cerebro-intensiva", in *Competencia*, Buenos Aires, October 1976 and "Electrónica. La industria electromédica argentina", in *Medicina y Sociedad*, Buenos Aires, 1979; Philip Maxwell, *Consideraciones sobre las ventajas comparativas de la industria electrónica argentina*, INTI, Buenos Aires, 1979 (unpublished); Silvia Helena, *A industria de computadores: Evaluçao das decisoes governamentais*, and Iván Da Costa Marques, "Computadores: parte de un caso de sobrevivencia e da soberanía nacional"; in *Revista de Administraçao Pública*, Getulio Vargas Foundation, Rio de Janeiro, October-December 1980.

[39] In 1980, the United States produced 64% of the total output of integrated circuits of the whole group of market-economy countries, while Japan produced 25%; they were followed by the Federal Republic of Germany, France and the United Kingdom. When the remainder of Western Europe is added, this brings the figure up to 99% of the total output of integrated circuits by the market-economy coun-

participation of the State as the executing agent of research and development projects, however, is much less, thus indicating the importance of public financing in this branch of public activity. In the United States, for example, 51% is financed by the State, but the latter only executes 16%[40]. In addition to the support it gives to research and development, the State plays an important role through the planning of purchases and their orientation towards domestic firms.[41] In the United States, the State has also been a key factor in microelectronics training. In the leading countries, the State action with regard to the electronics complex includes specific project and sectoral policies, the long-term planning or execution of strategic activities, the establishment of co-ordination bodies, the maintenance of close links between the industry and the government, support through direct aid and purchases, and promotional measures.[42]

Although there are no quantitative estimates for appraising State support to local electronic development in Latin America, the available information reveals a marked contrast between the attitude of the leading countries and those of the region. The United States *Buy American Act*, for example, gives United States products a preference margin in State purchases which is double that given in Argentina.[43] Although public bodies do exist in the countries of the region which have direct or indirect competence in the field of the development of the electronics complex, all of them suffer from insufficient financing, inadequate linkages with the private sector and with other bodies in the country, insufficient access to high levels of government or capacity to influence economic policy, or all these shortcomings at the same time.[44]

The main exception to the above remarks is Brazil, both because of the high administrative level and wide competence of the Special Secretariat for Informatics and its influence on the computation industry of the country and because of the set of policies which have contributed to the rapid development of its electronics industry since the mid-1960s. The change in the relative positions of Brazil and Argentina is due fundamentally to the differences between the public policies of the two countries.

The orientation of public sector purchases has an effect on the electronics complex which is difficult to exaggerate.[45] State purchases influence the technology, the development of the industry's suppliers, and the equipment of the private sector which uses public services. When an administrative decision regarding telecommunications is taken which provides for the supply of a new service, State purchasing policy determines, on the one hand, the demand and technology of the central systems and, on the other, that of the peripheral equipment of users and its interfaces with the public system, with which it must be compatible. In this way, the State orients the technology in use towards that of the suppliers which it chooses and gives them other competitive advantages in the domestic market, such as

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tries, 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 the Socioeconomic Impact of Microelectronics Technology, already referred to.

[40] These percentages refer to the whole of research and development activity, but they are considered to be the same or higher in the case of microelectronics. In 1975, the five leading countries were responsible for 60% of total world spending on research and development; see Fabio S. Erber, "Desenvolvimento tecnológico e intervençao do Estado: un confronto entre a experiencia brasileira e a dos países capitalistas cetrais", in *Revista de Administraçao Pública*, Getulio Vargas Foundation, Rio de Janeiro, 1980.

[41] The Japanese telephone administration (NTT) reserved 100% of the market for Japanese enterprises up to the year 1980, by which time Nippon Electric was the second world producer in the telephone field. See *Business Week*, December 1980, and John Bessant, *op. cit.*

[42] John Bessant, *op. cit.*

[43] See Fabio S. Erber, *op cit.*; Decree No. 5340/63, and Law No. 18875 of Argentina.

[44] See Pradeep Bhargava, *Report of the visit to Venezuela and Mexico under the UNDP Fellowship*, Government of India, Department of Electronics, New Delhi, 1976 and Juan Rada, *The Impact of Microelectronics and Information Technology with Reference to Brazil, Argentina and Bolivia*, UNESCO, October 1980.

[45] In 1975, the purchases by public administrations amounted to more than 40% of the overall demand for electronics in the world. Although no exact estimates are known for Latin America, the proportion here would appear to be even higher; see OECD, *Interfutures. Final Report*, Paris 1979, table 53.

the prestige and the 'critical mass' for competing in the private sector.

In actual fact, hardly any use of this power is to be perceived (although one way or another it is already being exerted) in favour of the development of the electronics complex in the region. This is largely due to the lack of departments specializing in technology which can increase the capacity for developing technological options in public sector enterprises and bodies. This same limitation makes it technically impossible to 'untie packages', with a consequent tendency towards turnkey purchases, thus strengthening for very obvious reasons the exogenous nature of the incorporation process. Moreover, it may be noted that public service enterprises take into account as their objectives only the provision of the service and the cost of the equipment, thus neglecting purchases which could favour the local development of the electronics complex.

Any policy which aims to develop the electronics complex in the region must take account of the above considerations. The present structure of public administrations makes the process of selective endogenization more difficult because of, *inter alia*, the already mentioned tendency towards turnkey purchases and the reduction of technological decisions to the minimum possible.[46]

In order to establish a strong interaction between the public and private sectors, along the style of that existing in the leading countries, some mechanisms should be established in order to link public bodies and enterprises with local private firms and with technological institutes and universities. With the same objective, a co-ordination and planning body should be set up on which the private sector is represented.

In Brazil, efforts have been made to progress in this direction through the establishment of the Industrial Linkage Nuclei (NAI), of which 113 –reporting to a co-ordinating commission– had been set up by 1978. It has been considered, however, that their objectives were only partially fulfilled because of the "lack of a policy giving preference to domestic enterprises" and the "frequent distance of the NAI from the decision-making centres of enterprises".[47] All this shows that the development of the electronics complex calls for integral and suitably co-ordinated treatment, as well as an institutional system which tends to facilitate this.

The 'Buy Argentine' and 'Buy National' system may be noted as another example of action in this field.[48] Although it contained many of the purchasing policy elements which are to be recommended ('untying of packages', design and planning as a function of domestic supply, price preferences for local equipment, etc.), it has not had a substantial effect on the development of the electronics complex in Argentina because the aforementioned limitations militated against its proper application.

The effect of such action on the development of enterprises may be decisive, because it provides a 'critical mass' which helps technological development and competition on the private market; because it produces a demonstration effect typical of public purchases; and because it generates an interaction fostering the search for technological options which are different from those offered by the transnational corporations. Moreover, the impulse given to these local enterprises would substantially improve their possibilities of supplying large private users.

Certain markets are directly influenced by the State even when the public sector is not a significant purchaser. Thus, even when telecommunications services are not provided by the State, for example, there is nevertheless a tendency for the State to lay down the regulations for the services and the technical specifications of the equipment to be marketed. This is due to the application of

[46] See A. Araoz, J. A. Sábato and O. Wortman, *Compras de tecnologías 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.

[47] Fabio S. Erber, *op. cit.*

[48] Based on Decree No. 5340/63 and Law No. 18875 of Argentina.

criteria aimed at the rationalization of the radioelectric spectrum and other considerations of national defence and consumer protection.

This intervention does actually influence the technologies adopted and the possibilities of local development, so that it can be used to rationalize the incorporation of technology and to try to ensure that it is the most suitable for the needs and possibilities of users. Furthermore, it should be borne in mind that this intervention takes place in respect of equipment and systems for which there is an important development potential in the region,[49] and in respect of which it is most necessary to adapt the type of goods supplied by developed countries (in rural areas or small towns). In addition to the example of telecommunications, there are those of the market for health and educational equipment, which have similar problems and potentials.

Decisions on industrial protection and promotion in the electronics field must take into account the international context and national and regional requirements. The use of the international prices of goods and systems as a parameter for taking decisions on purchases and investments, for example, is of very dubious justification for three main reasons. The first is that these prices are largely determined by the public financing of research and development in the leading countries and the reduction in risk brought about in those countries by the public sector purchases and the direct and indirect protection of national markets. Secondly, this blurring of the price as an indication of efficiency and private costs is made worse at present by the trade war between the developed countries, which is particularly intense in the case of electronic products. Finally, the purchase price is only a part of the final cost of a piece of equipment or system, which is determined above all by the level of utilization and the cost of use. Consequently, decisions should not be based on the purchase cost of goods so much as on an analysis of their suitability for national needs and possibilities and the indirect effects of each option on development as a whole.

(d) *Technological training and information*

The transfer of technology can be a very important channel of technological training and information, but only if the technology really is transferred, that is to say, if the country paying for it really does come to master its substantive and operational aspects. In reality, what is usually described as the transfer of technology is quite different: it may refer to payments by subsidiaries to the headquarters of transnational corporations, or payments in respect of the marketing of a particular good. With regard to the first of these cases, it should be noted that it is difficult to justify such payments, because the corporation has already amortized the technology in question, and it may be recalled in this respect that the legislation of some Latin American countries does not permit such transactions. As regards the second case, it may be considered that such payments should only be authorized when they are really justified.

With regard to the technology which is incorporated in the equipment, special care needs to be taken, as this often constitutes the starting point of chains of technological determination of ever-increasing cost. The relation in this case would also be of a continuous nature, but increasingly onerous for the recipient. This is probably what will happen with the new telephone systems now being installed in the larger countries of the region.

A specific form of the search for technology is 'technological intelligence'.[50] In the case of microelectronics, this way is particularly suitable, because commercially available technology exists and there is a possibility of making use of it on the basis

[49] J. Mauro and H. Nochteff, *Informe sobre el sector de radiocomunicaciones*, Buenos Aires, 1980 (unpublished).

[50] These observations are based mainly on the statement delivered by Ward Morehouse, *The Third World in Silicon Valley*, at the First Latin American Seminar on the Socioeconomic Impact of Microelectronics Technology, Buenos Aires, 9-11 December 1981.

of the development of engineering capacity in the countries of the region. Specifically, in the developed countries there are academic and research institutions which provide technological services in the electronics area and small consultancy enterprises formed by ex-members of the semiconductor industry who provide technological and marketing information on a commercial basis. There is also a possibility of acquiring technology directly from small or medium-sized but technologically-intensive enterprises.

In order for the bargaining capacity of the enterprises of the region to be successful, it should be increased through the economic and technological support of governments, as well as international co-operation action.

The technological centres of the region have insufficient links with the major users of electronics and local producers. This is due largely to the very limited demand for technology deriving from the exogenous nature of its incorporation, which makes it difficult to co-oordinate the efforts of the centres, as there are no poles of demand sufficiently important to influence trends in the supply of technology. One of the fundamental ways of reversing this process would be to concentrate efforts to set up technological centres among major public users and bodies which take decisions on matters directly linked with priority areas of the electronics complex, such as the centres dealing with technical regulations regarding information services, communications, education or health, or those dealing with policy on the electronics industry. In order to be effective, these centres should have decision-making power or be closely linked with those responsible for taking decisions, and they should establish formal relations with the private sector so that interaction with local supply possibilities is a central and not a residual function.

These centres would influence incorporation into the private sector only indirectly, so that a policy on technological and productive information is indispensable in order to increase the potential advantage derived from the electronics complex in the private sector, speed up its incorporation, improve its utilization and, in certain cases, orient demand towards local industry.

The brain drain in connection with the electronics complex is particularly intense because of the growing disparity between the development of the electronics complex in the developed countries and in the countries of the region, as well as the relative scarcity of software in the developed countries, which leads them to increase the offers designed to secure the migration of skilled personnel.[51]

In the case of Argentina, it may be estimated that approximately 25% of the electronics professionals who have graduated since 1950 have emigrated.[52]

The reversal of this flow can be one of the ways of incorporating technology, since the available data give grounds for assuming that a considerable proportion of the professionals who have emigrated are currently working in research and development, either in industry or in the academic institutions of the developed countries.

(e) *The role of the transnational corporations*

The assignment by the transnational corporations to different countries of the roles of producers, exporters or mere consumers of microelectronics is frequently decisive, especially in the absence of national policies in this respect.

The transnational corporations must be brought in line with national development policies, objectives and local priorities, to the achievement of which they must make a positive contribution, as well as helping to create scientific and technological capacity in the host countries. In order for this to take place, it is essential that the countries should define their objectives and priorities and specify in them the particular contribu-

[51] Hugo Nochteff, "El efecto Mateo", *Informe Industrial*, Buenos Aires, 1981.

[52] Estimates based on data from A. Dmitruk, E. Elisetche, A. Godel and N. Prieto, *Recursos humanos en electrónica*, presentation made at the Congreso del Programa Nacional de Electrónica, Buenos Aires, September 1981.

tion of the transnational corporations. Once the role assigned to such corporations has been defined, their co-operation can be actively sought, both in the case of firms already installed in the country and in that of other enterprises of different size and origin.

Negotiations with the transnational corporations are usually complex and not necessarily easy, but they are nevertheless important points of coincidence between those enterprises' desire to optimize their profits and the fulfilment of national objectives. The establishment of clear priorities and rules for each case makes it easier to come to an understanding on such co-operation.

The centralization of the national negotiating position is of great importance and saves time and avoids misunderstandings; the various problems involved in negotiations with transnational corporations should, as far as possible, be dealt with and solved simultaneously.

(f) *International co-operation*

Microelectronics is a particularly promising field for international co-operation between countries and institutions of the Third World in general and of Latin America in particular. The similarities between the problems facing the different groups of countries and the need to achieve the necessary scales and 'critical masses' should help such co-operation, both as regards the development and the incorporation of this technology.

National policies should stimulate international co-operation on these matters between the countries of Latin America and those of other developing areas. They should also promote the exchange of information, the establishment of pilot programmes and the conclusion of technology agreements with developed countries.

The transfer of technology and know-how between countries of different levels of electronics development should be systematically explored and steps should also be taken to organize joint development projects in connection with specific problems of the countries involved.

Common treatment of transnational corporations could gradually be introduced so as to ensure the achievement of certain minimum objectives in this respect. In order to do so, the Latin American countries should reach some degree of consensus on a more general strategy for the development of the electronics complex.