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Notes and explanation of symbols

The following symbols are used in tables in the *Review:*
Three dots (...) indicate that data are not available or are not separately reported.
A dash (—) indicates that the amount is nil or negligible.
A blank space in a table means that the item in question is not applicable.
A minus sign (-) indicates a deficit or decrease, unless otherwise specified.
A point (.) is used to indicate decimals.
A slash (/) indicates a crop year or fiscal year, e.g., 1970/1971.
Use of a hyphen (-) between years, e.g., 1971-1973, indicates reference to the complete number of calendar years involved, including the beginning and end years.
Reference to "tons" mean metric tons, and to "dollars", United States dollars, unless otherwise stated.
Unless otherwise stated, references to annual rates of growth or variation signify compound annual rates.
Individual figures and percentages in tables do not necessarily add up to corresponding totals, because of rounding.

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Notes on microelectronic automation in Brazil

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The objective of this work is to evaluate the results of the principal investigations conducted in recent years on the socio-economic implications of microelectronics-based automation in Brazil, and in particular the investigations carried out by the author himself.

These investigations focussed on the quantitative and qualitative impact produced on labour and on patterns of accumulation by the dissemination of microelectronics-automated equipment in Brazil; the link between external restrictions, automation and employment; the relationship between microelectronic automation and competitiveness; and lastly, an evaluation of the main socio-economic questions inherent in the dissemination of the microelectronic technical base in Brazil.

A very brief section describes some of the technological-industrial and labour conditions existing in Brazil prior to the more intensive dissemination of the new technical base in the early 1980s. The next section characterizes this decade as particularly important for the Brazilian economy and presents some dimensions of the crisis, the levels of dissemination of microelectronics-automated equipment, the volume of employment related to them and the sources of competitiveness that led to a sudden increase in the export of products of local industry. The three subsequent sections give a more detailed but brief analysis of three complexes: first, textiles, clothing and footwear; second, metal-mechanical work; and third, electronics. In the last section we raise two fundamental problems to define the directions in which the Brazilian economy is to develop during the coming decades: the updating of capital-labour relations and the integration of industrial and technological policies.

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Introduction

Brazil entered the 1980s with an industrial base of large proportions and with a reasonable degree of complementarity in the production system, from consumer goods for workers to sophisticated producer goods used for producing other capital goods. For at least three decades, using essentially electromechanical techniques, Brazilian industrialization was reflected in high rates of economic growth, averaging about 7% per year. Throughout this period, growing numbers of workers were incorporated into the capitalist production system, becoming consumers. In spite of this, income distribution grew worse, to the advantage of a population class which became smaller and smaller in numbers and more and more wealthy.

Social relationships in the production sphere followed two basic paths. On the one hand, the physical organization and the methods of production were reflected in the theories of Ford and Taylor, although it was still necessary to make many adaptations because of local characteristics.

Thus the constant improvisations necessitated by technical change implied a fairly versatile labour force that could enable a previously existing quasi-handicraft-agricultural technical base to coexist with an electromechanical base that was being established. In these terms, highly skilled workers created concrete possibilities for the installation and functioning of a manufacturing base which is already one of the eight largest in the world.

On the other hand, capital-labour relations in Brazil were formalized by the law, under strong co-operativist influence, when the country began to pass through the first convulsions of the replacement of industrial-goods imports during the 1930s. The changes in labour legislation up to the present decade tended in general to favour the populist and/or authoritarian interests of the governments. In essence, under these conditions, the creation and growth of an industrial labour force were not accompanied by an adjustment of labour problems to the functioning of an industrial economy that was only minimally developed. So-called "white unionism" was the norm and not the exception; in

addition to this, the long period of continued industrial expansion concealed a series of questions inherent in the dynamics of a modern capitalist economy. A clear example of the foregoing is the fact that problems characteristic of a mature industrial economy, such as technological unemployment, possibly associated with the process of modernization, never arose because the economy and employment were expanding so rapidly.

I

The introduction of microelectronics-automated equipment (MAE) in Brazil and the question of competitiveness

The decade of the 1980s is significant for the Brazilian economy because of at least three factors. At the beginning of the decade there was a severe economic crisis which, for the first time, caused high levels of industrial unemployment in the country. A typical example was the 30% drop in the production of motor vehicles between 1980 and 1981, which resulted in the unemployment of 25% of the labour force in this leading industry. Another characteristic of the evolution of this crisis was the high degree of external indebtedness that developed, with the result that the economy came to be oriented more towards exports in order to obtain foreign currency. Using exports as a way out was also more or less "natural" for many of the enterprises that saw the utilization of their productive capacity decline suddenly with the withdrawal of domestic demand. In actuality, this withdrawal immediately created a need to increase the efficiency of these enterprises. Thus, merely as a matter of survival, they were forced to reduce the amounts needlessly spent on fixed capital, circulating capital and personnel, to improve the productivity of these factors and to seek new markets for their activities. Many did so by means of exports, which in turn required an improvement of competitive capacity, either through an appropriate cost structure, through a pattern of quality indispensable to certain markets, or through the capacity to deliver goods on time within agreed time-limits.

This means that while foreign-exchange policies were decisive, on the one hand, in making a number of manufactured products competitive during certain periods, this competitiveness also arises from the specific comparative advantages of the various industrial complexes that existed in the Brazilian economy (Erber, F., Araujo Jr., J. T., and Tauile, J. R. 1985). Thus, the iron and steel industry, the petrochemical industry and the cellulose-and-paper industry, all of which sell intermediate products and whose production is organized basically in the form of continuous flow (in other words, with low labour-intensity), are favoured by the "technical age of productive capacity". They benefit "especially from the modernity of the installations constructed in the recent past" (*ibid.*), as well as from the availability and low prices of local inputs (and obviously also of the minimal production scales already attained locally).

The products of the textile/clothing/footwear complex derive their competitiveness chiefly from the relative cost of local resources. "Intensive use is being made of relatively abundant natural resources (for example, fibres and hides)" and especially "relatively cheap manpower" (*ibid.*).

There are also a number of manufactured products (requiring a reasonable amount of technological processing) within the metal-mechanical complex, such as producer goods, weapons and durable consumer goods, which, in addition to requiring sufficient technological skill —something that already existed in the country— satisfactorily meet the demand of specific markets sufficiently akin or similar to the characteristics of Brazilian markets. In this context, a substantial share of such exports is intended for "trade between peers", with countries whose degree of development is close to or lower than that of Brazil, although it also

extends to market niches in the so-called developed countries of the North, as evidenced by the export of aircraft and of automobiles and auto parts to those countries (*ibid.*).

The second outstanding factor for this analysis relates to the increase in the levels of dissemination of microelectronics-automated equipment (MAE). In general, a policy for the local and national development of production training in the field of electronic data-processing equipment (EDP) began in the 1970s, on the basis of an implicit "alliance" between segments of the armed forces (especially the navy) and Brazilian intellectual élites with technical training, engaged in professional activities, particularly in information science. The generally accepted view of this movement was that Brazil was facing a strategic problem that involved national security, in various aspects (military, economic, social and the like). Convinced of this perception, at the end of the decade the military government created a Special Secretariat for Information Science (SSIS) [*Secretaría Especial de Informática* (SEI)] at the ministerial level in order to formulate and carry out policies for this sector.

With regard to MAE, implementation of the policy formulated by SSIS began during the 1980s, pursuing the successive objectives of technological and industrial training for the production of digital control boxes (DCs), logically programmable controllers (PCs), computer-assisted design installations (CADs) and industrial robots. This policy has been based on the purchase or initial licensing of technology by Brazilian enterprises which would later make a concentrated effort to absorb it in a relatively short period (four to five years) and develop it, thus creating national skills. It is not yet possible to make a convincing analysis of the results of this policy. Actually, some skills are being created, since at least 90% or so of the digitally controlled machine tools (DCMTs) and almost all the PCs put into operation in 1985 had been manufactured in the country. However, such equipment is still very expensive in comparison with foreign equipment of the same kind. It is argued that this is due to inadequacy of scale and to the high cost of materials and components, but the lack of competitiveness in a protected market may be responsible for a significant portion of this difference in price.

The rates of dissemination of DCMTs and PCs remained stable during the early part of the 1980s. This was followed by a movement that included two opposing trends. On the one hand, financial difficulties inhibited investment in new equipment, while on the other hand, the search for greater productivity stimulated it. In any case, beginning in 1983-1984, with the recovery of growth, the dissemination rates increased (including CADs and robots) and caused a progressive and intensive utilization of local productive capacity. The amount of installed MAE in 1985 was estimated at 1 600 DCMTs, 1 600 PCs, 70 large-capacity CADs and 20 industrial robots (Tauile, 1986a).

More recent data obtained from the Brazilian Society for Digital Control and Industrial Automation (*Sociedade Brasileira de Comando Numérico e Automatação Industrial* - SOBRACON) show that in 1987 Brazilian manufacturers sold 1 018 DCMTs (worth about US$200 million) on the domestic market, bringing the inventory of this type of equipment up to 2 928 units (*Boletim SOBRACON*, Vol. IV, No. 37/38, 1988). This source indicates that 71 large graphical computation systems (CAD/CAM) and 540 small ones, based on microcomputers, were sold in 1987. Sales amounted to approximately US$8.2 million and US$20.8 million respectively, and installed equipment in that year included 190 large units and 732 small units. In the area of robots, 18 units, with a total value of US$45.1 million, were sold in 1987, raising the existing inventory to 87 installed units. As for logically programmable controllers, notwithstanding the difficulty of recording a large variety of models and applications, SOBRACON estimates that invoiced sales amounted to US$32 million.

The increase in the levels of dissemination of MAE also means that a larger number of workers are carrying on their activities by using the microelectronic technical base. In 1985 approximately 220 000 workers were employed on various microelectronic data-processing units (Tauile, 1986a). In the light of the accelerated dissemination of such units from that time on, it may be estimated that the number of workers associated with this field is now over 300 000. This brings us to the third fundamental axis of the analysis: it is becoming increasingly urgent to improve capital-labour relations in Brazil,

with the appropriate institutional approval. The opportunity is almost unique, or at least particularly favourable for this, owing to the process of liberalization and democratization of the political reégime and of the présent installation of a National Constituent Assembly. However, before analysing this aspect, we shall give an overview of the process of dissemination of MAE in terms of some of the fields in which it is utilized and the respective factors which stimulate or retard the dissemination of this type of equipment in Brazil.

II

The dynamics of dissemination through industrial complexes

1. *The textile/clothing/footwear complex*

In this complex the dissemination of MAE is still very low and is not essential, in the short term, for guaranteeing the current pattern of competitiveness of enterprises, in relation either to the domestic market or to the foreign market. In the latter case, as mentioned before, competitiveness derives from the availability and low cost of these factors, particularly manpower, and on the other hand, the dissemination of MAE in this complex is still limited at the international level; there is no expectation that relevant structural modifications will come in the short term as a result of some spectacular technological advance.

a) *The textile sector*

In the case of the textile sector, the use of microelectronic devices does not radically change the organization of production. All it does is accentuate the already existing tendency, even in the electromechanical base, to assimilate it to a continuous flow of production. Owing to the diversity of the demand structure, the corresponding production base is also fairly heterogeneous, and the enterprises which cater to the foreign market are in general the ones with a concentration of more modern and advanced equipment. However, the use of such equipment is not yet being considered for the exports of this sector. Actually, as a result of the crisis of the early 1980s, and stimulated basically by currency policies, many enterprises have succeeded in penetrating the foreign market, so that exports in 1985 were up to US$1 billion, which represents 30% of the sector's output (Tauile, 1986b).

The main reasons that motivate entrepreneurs in this sector to introduce microelectronics-based automation are: higher quality required to compete in foreign markets, greater control over the production process and greater competitiveness. Among the obstacles are: the high cost of automated equipment, the difficulties of importing it, low wages and the ability to compete in the domestic market with less sophisticated equipment (*ibid.*).

b) *Clothing*

With regard to the ready-to-wear clothing sector, as in the preceding case, the profile of domestic demand is fairly heterogeneous, although this has already been catered to by an extensive production structure which includes countless microenterprises and small enterprises. The exports of the sector were slightly less than 1% of the total amount of manufactured goods exported in 1984.

In any case, even on the international scene, the degree of integration between the various steps of the production process is low, the utilization of manpower is still intensive, and no rapid dissemination of MAE is foreseen; it tends to be concentrated in the area of production management and in the optimization of fabric-cutting (Tauile, 1986c). In the Brazilian case, savings on manpower, which —as mentioned before— is very cheap, do not constitute a strong incentive, although savings on materials

may be significant. This also means that the reasonably simple CADs used for the optimization of cutting may be supplied perfectly well by local industry.

Among the factors that stimulate the utilization of MAE in the sector are: simplification of the initial tasks of the production process, savings on materials, savings on skilled labour for preparation, better quality of the final product and creative flexibility for launching new models, in addition, naturally, to efforts aimed at an increase in competitiveness and the recovery of the economy.

With regard to the factors that discourage the introduction of MAE, in addition to the recent economic crisis, which caused a general postponement of investments for the expansion of productive capacity, we should mention: the low cost of manpower, the high cost of the MAE, the cost of training the operators and the difficulties in maintenance (Tauile, 1986b).

Lastly, entrepreneurs argue that both in the clothing sector and in the textile sector, the lack of a well-defined technological policy has retarded the process of dissemination of MAE.

c) *Footwear*

The manufacture of footwear also makes intensive use of manpower (it employs 3.2% of the labour force in the processing industry, but it represents only 1.5% of the aggregate value). The great majority of the industry consists of microenterprises and small enterprises, with a total of more than 4 500 firms. Of this total, however, scarcely more than 300 are exporters, although they account for a relatively high share in comparison with the rest. The foreign market has grown in importance for this sector, which is already responsible for more than 7% of the exports of manufactured goods. More than 25% of the sector's output is exported, and over 80% of this amount is sent to the United States. On the other hand, it should be noted that the producers do not control the export channels (*ibid.*).

In technological terms, it may be said that in the manufacture of footwear "hand-made" is a synonym for high quality, and this is contrary to one of the main grounds cited for the use of automated equipment. The Brazilian footwear industry has incorporated few of the most recent microelectronics-based technological innovations, of which there are not many in any case. Even with regard to automated design for the modelling and development of products, there are no indications of any significant dissemination in Brazil. Some of the possible stimuli for automation would be: precision, flexibility of the production line and reduction of leather-cutting costs (flexibility is the most important stimulus in Brazil at present).

Among the discouraging factors, the most important is the irregular nature of leather, as a result of which cutting by hand is still indispensable. Moreover, in this sector too, the low cost of manpower, the small scale of the producing units and the low degree of specialization are important factors which retard the dissemination of MAE. It should be mentioned here that entrepreneurs in this sector take little interest in the possible importance of microelectronics-based automation for the success of their business.

2. *The metal-mechanical complex*

The dissemination of MAE through the metal-mechanical complex has contours which are better defined, both internationally and in Brazil. It has already reached higher levels and is of much greater importance than in the textile/clothing/footwear complex. In the sectors of the metal-mechanical complex the limits of automation traditionally established by electromechanical devices were overcome by the development and introduction of MAE (Tauile, 1986a). The consequences, both at the product level (quality and diversification) and at the level of organization of production (profile and volume of employment, control of the process, etc.) and at the level of cost structure (economies of scale, productivity, etc.) significantly altered the patterns of competition, mainly in the international sphere, where new microelectronic techniques are already more widely disseminated. The following sectors, although they belong to the same complex, have very different characteristics, both with regard to the structure of ownership or demand and with regard to the scale and organization of production.

a) *Machine tools*

The manufacture of machine tools has been affected to a considerable extent by the dissemination of the new technical base. To begin with, the machine-tool sector itself, in addition to being the producer of MAE, is also one of its principal users. In Brazil this sector had reached a level of internationally recognized competitiveness in the 1970s on the basis of electromechanical equipment, most of which was owned by Brazilian private capital. Of the 102 locally established enterprises in 1975, 18 were foreign subsidiaries, and half of these were German. Several of them had been recently installed as a result of the stimuli of the Second National Development Plan, which was intended to consolidate the formation of a capital-goods sector in Brazil. Although the foreign enterprises were not the largest ones, they specialized in the production of more advanced and more complex equipment, and this remains true to the present day. Nine subsidiaries of German enterprises are responsible for about 60% of the production of DCMTs (Stemmer, 1985), which in 1987 had reached the level of 800 units produced per year.

Even though the portfolio of machine-tool orders has been systematically kept full, so that the sector could grow substantially and make new investments in equipment (in addition, as has been mentioned, to being the sector which made extensive use of DCMTs), prices remain significantly high: they were two or three times as high as those of similar equipment sold on the international market (even the equipment made by the German subsidiaries' parent companies). This is curious, since the alleged reasons of high material and component costs and small-scale production cannot cancel the savings derived from the use of cheap labour. It is useful to remember that this type of production makes intensive use of skilled labour, which is fairly easy to find locally.

In the face of import difficulties, it is worth mentioning that the high prices of locally produced MAE continue to be the greatest obstacle to its dissemination in Brazil. On the other hand, the rapidity of the dissemination creates a relative but transitory shortage of skilled labour to operate, maintain and program them.

The principal stimuli for making the sector adopt MAE are related to the guarantee of precision (and of quality) afforded by the complex units used for production and by the economies of scale, that is to say, the flexibility of rapidly reconvertible equipment, which is very important in small-scale production.

Machine-tool producers have made efficient use of their MAE, sometimes even using experiments with group technologies, automated cells, etc., which produces a sort of technological convergence and apprenticeship in economies of scale (even though there is no complete flexible manufacturing system now installed in Brazil, nor are there any plans to install one).

Three other facts with regard to this sector should be mentioned here. In the first place, there is a shortage of simpler and cheaper MAE, to meet the demand from many small and medium-sized enterprises and enable them to take advantage, at least partially, of the skills of the existing labour force (Tauile, 1984a).

In the second place, the international competitiveness of the sector has been severely shaken, either because MAE has taken conventional (electromechanical) machine tools out of the market and local industry has not yet managed to reconvert efficiently or because the principal purchasers (which are also developing countries, such as Mexico) were badly hurt by the crisis of the early 1980s. In fact the exports of the sector during the first half of this decade were reduced to barely one quarter of the 1980 level and show no signs of recovery.

Lastly, there is some fear that the change in the technical base may stimulate the process of centralization of the industry, to the benefit of the most capable and financially solid enterprises and of those which are the most dynamic technologically. This process would favour large enterprises and the subsidiaries of foreign enterprises. Moreover, this problem is not limited to the manufacture of machine tools; as the nucleus of a technological convergence, it radiates into problems similarly encountered in the rest of the economy (*ibid.*).

b) *The automotive industry*

The automotive industry is led by four major transnational assembly enterprises which practically dominate the entire automobile market in Brazil. There are three other large assembly

enterprises of European origin which specialize in the production of commercial vehicles (buses, trucks, etc.). In the automobile-parts sector, participation by Brazilian private capital now constitutes the majority, even though some of the major enterprises are subsidiaries of important transnational firms.

In 1980 the industry produced almost 1.2 million vehicles, which indicates a reasonable degree of industrial maturity. However, both the models offered and the methods used to produce them were still lagging substantially behind the internationally prevailing patterns. The sharp drop in production during the following year forced the assembly enterprises to redefine their strategies in order to guarantee better and more effective utilization of their productive capacity. The choice generally made was to produce models similar to those produced in the developed countries, so that they could also be exported, thereby creating a flexibility that would enable the enterprises to reduce the under-utilization of their installations (Tauile, 1984b).

It can be said that from that time on, the Brazilian automotive industry entered a new phase of its development, a phase of greater integration into international industry. By 1981, exports had doubled, reaching almost 27% of total production, and thereafter they decreased slightly, although never to less than one fifth of total production. From 1982 to 1983, General Motors and Ford launched their "world cars", in which they were followed in 1984 by FIAT and VW (which does not agree that "world car" is a novel concept and had in fact been producing more up-to-date models since 1980).

The production of the new models was accompanied by the introduction of new production lines and MAE such as: robots, DCMTs, flexible transfer-machine systems, flexible multiple welding systems, magnetic-car transport systems, air transport systems, automated systems for final tests of vehicles, real-time control systems for production flows and the flows of intermediate inventories, etc. In actuality, a development as important as or more important than the introduction of these types of MAE was the generalized effort to make production more efficient, avoiding waste and reducing the formation of inventories, through the introduction of adapted forms of "just-in-time" (or "kanban") systems. This search for efficiency and modernization affected both assembly enterprises and suppliers of automobile parts, and it certainly resulted in production patterns (quality, capacity for on-time delivery, cost, etc.) which were closer to the international patterns for this industry (*ibid.*).

Although Brazil still does not have a mass dissemination of MAE that can measure up to the levels of developed countries, the level is already becoming significant in relation to Brazilian patterns. Assembly plants were pioneers in the use of robots. DCMTs are coming to be more widely used by the tool-making shops of assembly plants and by the producers of auto parts, chiefly for trucks (small scale) and/or for the foreign market, and programmable controllers are being put to the most diverse kinds of use on the production lines of both sectors (*ibid.*).

In any case, all the assembly plants recognize that this is a phase of apprenticeship in the new technical base, so that MAE may be even more intensively and efficiently used in future production lines manufacturing new models. The main incentives for its utilization involve guarantees of quality, greater control of the production process and greater flexibility of the production lines. The main disincentives are the low cost of the labour that can be replaced by automated equipment (by robots, for example), the high cost of such equipment, and the productivity of such equipment and of the production lines previously in operation.

c) *The aircraft sector*

In the aircraft industry the main Brazilian enterprise (a State enterprise) has no need, in terms of quality of products and up-to-date status of production processes, to envy other enterprises in the world that operate in the same market sector. EMBRAER has been using DCMTs since the first half of the 1970s and has been using automated design since the beginning of the 1980s.

Fundamentally the MAE in this industry is justified by the absolute requirement for precision and high quality that must be satisfied by anyone who wants to sell aircraft (chiefly on the international market), by the small scales of pro-

duction and by the flexibility required of the equipment. Owing to the characteristics of the necessary production techniques and to the fact that it is State-owned, this enterprise initially enjoyed special facilities for importing foreign equipment, thus staying close to the international state of the art.

Among other factors making for the technological success of EMBRAER are: strong military (air force) support, the proximity and integrated support of the Research and Development Institute of the Technological Centre for Aeronautics (*Instituto de Investigações e Desenvolvimento do Centro Tecnológico de Aeronáutica*) and the training of engineers by the Aeronautical Institute of Technology (*Instituto Tecnológico de Aeronáutica*). Lastly, it should be mentioned that the market was protected by a prohibition on the import of any aircraft similar to those produced by EMBRAER.

EMBRAER has collaborated closely with Italian companies, obtaining technological licenses or participating in joint projects (as in the case of the AMX. Until recently almost all the avionics components of its aircraft were imported. The policy of nationalizing its production has stimulated the granting of licences by Italian enterprises.

3. *The electrical-electronic complex*

MAE has not yet been utilized to any significant extent in the production of computers and telecommunications equipment (the electronic complex), chiefly because of the lack of large-scale production.

a) *Computers*

In recent years the Brazilian computer industry has grown, been nationalized and become deconcentrated. From 1973 to 1985, Brazilian enterprises, which accounted for 23% of the market, grew in geometric progression at an average rate of 59% per year (as opposed to 7% for the multinationals) until they possessed more than 50% of a market estimated at US$2 billion and employing more than 30 000 workers (more than one-third of whom are highly skilled). The five largest enterprises, which had controlled 88% of the market in 1974, were reduced to 46% in 1984.

In terms of technological updating, the products are not too far behind international patterns. In 1984 the lag of the microcomputers produced in Brazil was approximately one year, but it was longer for minicomputers and peripheral equipment (Tigre and Perine, 1984). This performance, which actually was not maintained at the same level, is attributable to the high technological skill of some national enterprises and to the fact that the main components can be acquired on the international market.

Production processes are falling further behind the state of the art. The levels of automation are low; in general, production costs are high in comparison with those of other recently industrialized countries, a fact reflected in the poor performance of the export sector. In 1984, exports amounted to US$150 million, of which IBM represents about 80% (Tauile, 1986b).

As a result of the process of import substitution, which made the birth of the Brazilian computer industry possible, the capacity to design or adapt computers developed without any similar concern with production processes. Thus the market had a great diversity of models whose production was relatively small-scale and consequently could not be automated. On the other hand, the high costs did not represent any great problem, since they were passed on to the consumers, in the light of the fact that the market was protected from foreign competition and demand was only small.

As the industry develops, this picture is tending to become modified. Competition is growing with the entry of new firms which are contending for the growing market, and thus there is greater concern about the production process in general and about costs in particular. The increase in scale has not yet been reflected in the patterns of automation, chiefly because labour is very cheap. Indeed, priority for the use of MAE is justified not in terms of costs but in terms of improved quality, and above all in the advancement of design capacity. Thus a recent investigation showed that MAE is being gradually introduced into the areas of design, quality control and assembly (Hewitt, 1986). In the light of the lack of large-scale production, the costs of introducing MAE into the production of compu-

ters in Brazil are becoming prohibitive. Similarly, its introduction at the present time represents a high-risk investment because of the rapid obsolescence of present-day technology.

Despite the differences with regard to the history of its establishment and development, as well as the characteristics of the present industrial structure, the production of telecommunications equipment in Brazil is troubled by the same problems as the production of computers with regard to the introduction of MAE.

b) *Telecommunications equipment*

The telecommunications-equipment industry entered a new phase in 1974, when the government began to stimulate the development of a national segment of the industry and when microelectronics-based digital technology began to be adopted as a pattern. The principal instrument of policy was the monopsonistic power of the State, which was the principal purchaser of telecommunications equipment and which required its suppliers to prove that at least 50% of their circulating capital was Brazilian-owned. The main foreign enterprises in the sector "nationalized" their capital, becoming associated with large international groups in Brazil. A large number of telecommunications-equipment units, digitalized and/or microelectronics-based, were developed and produced since that time by the industry, in technological patterns not very different from the international ones. The fact that there existed a reserve of the market for computers, and that there was a technological convergence with computers facilitated the development of an authentically Brazilian segment in this industry.

In spite of all this, there is still an appreciable degree of technological dependency, and both in costs and in quality the lag behind the international state of the art is considerable. As mentioned earlier, the problems are basically the same as those faced in the production of computers.

The lack of large-scale production and the low cost of manpower are the principal obstacles to automation based on MAE, which should come gradually in the areas of design, quality control (testing) and assembly, in order that Brazil's telecommunications industry may become more competitive internationally (Tauile, 1986b).

III

Final observations

In conclusion, it is important to mention two points. The first relates to the updating of capital-labour relations in Brazil, and the second to the integration of industrial and technological policies.

The existing lag between a reasonably developed economy which is beginning to work with the microelectronics base and a labour legislation which goes back to the origins of import substitution in Brazil should be reduced, if not eliminated. In actuality, this is not so much a lag as a distortion provoked by rapid and continuous economic growth and a succession of populist or authoritarian governments which inhibited and repressed trade-union movements capable of genuine adaptation to the new production base that was being established.

In addition to higher levels of capital productivity resulting from industrialization, this also guaranteed even greater returns through the simple relative devaluation of work. In fact the electromechanical technical base that had been established with the industrialization of Brazil is incomparably more productive from the capitalist point of view than the quasi-handicraft base that had existed in the past. Moreover, much of the equipment installed by multinational enterprises had already been depreciated in its countries of origin and was being "revived" for a new accumulation cycle. The rates of profit related to their new utilization were thus potentiated, in view of the fact that in the numerator the fixed constant capital, referring to equipment, had been reduced almost to zero.

Lastly, the failure to improve labour legislation, as well as the incentive for corruption in the trade-union movement (in addition to wage reductions, etc.), represented in practice a reduction of the cost of social reproduction of the labour force, and therefore a new increase in the rate of research, which in turn increases even further the rates of profit prevailing with the new production pattern.

During the past 10 years the Brazilian trade-union movement has been rediscovering its identity. Initially there was absolutely no concern about technological factors, in view of the immensity of the other problems confronting workers in Brazil. Nevertheless, during the past five years, as MAE came to be more widely used, the principal trade unions have become more aware of the undesirable effects of the new wave of automation. It is interesting to note that the unions have never opposed the process of microelectronics-based automation, but they naturally want to safeguard their rights and guarantee for themselves a suitable share of the production gains made.

Entrepreneurs and production managers who are experimenting with equipment using the new technical base are coming to realize that they must be able to count on a more reliable, and therefore more stable, labour force. This would seem to mean that there is a way to negotiate new capital-labour relations in Brazil. It is not clear how much progress can be made within this context, chiefly because much of the industry is still developing in the traditional way and is being led by entrepreneurs with a conservative mentality and faults rooted in the long period of authoritarian rule which the country underwent recently. What is beyond question is the urgent need to make sure that the technological evolution of the production apparatus is based on improved and more compatible social relationships.

For all these reasons, it would be desirable that the democratic ideals expressed by the Brazilian people when it elected a constituent assembly should also be given tangible expression in a minimum body of laws to protect workers from the undesirable effects of the process of technological modernization, which will not be an undesirable process for them if it also brings effects that are in their favour. Moreover, this is obviously fair: if Brazil is using equipment which is already standard in the so-called developed countries, the existing labour laws should also be reformed to make them at least similar to the laws in force in those countries.

The second conclusion to be drawn relates to the integration of industrial and technological policies, in an attempt to maintain (and, if possible, to improve) the competitive capacity of Brazilian industry and also to promote a policy of effective technological training in the country, with a view to long-term economic and social development.

In actuality, the technological jumps produced by factors extraneous to the dynamics of the local economy should be avoided for the present, at least until labour legislation is brought up to date, so as to avoid creating distortions even greater than those mentioned. On the other hand, if the trend towards redemocratization of the country prevails, it is to be hoped that there will be a social appreciation of local labour, and consequently a gradual increase in real wages. Enterprises will probably try even harder to make their production processes more efficient and more modern. This means that there will be a continued incentive for the dissemination of MAE, since it is essentially through increased productivity that enterprises will be able to maintain their profitability.

This continuous increase in demand can be met in large measure by the local production structure, provided that there is sufficient incentive to make the necessary investments in research and development, in increased production capacity and, over the long term, even in the import of producer goods or particularly strategic production methods for the ordered development of the industry. What must be avoided is a situation in which the industrial sectors thus encouraged (principally enterprises of foreign origin) enjoy the benefits of an oligopoly as a result of the fact that protection of the market does not fulfil its objectives. In other words, after a period of implantation, production in the leading industrial sectors should be, if not at the advanced level of the international state of the art, at least within the range of costs that are compatible with those prevailing on the international scene. In the case of MAE there is no justification for incompatibility.

It would thus be possible to avoid excessive and unnecessary acceleration of Brazilian industry's competitive capacity, and an effort would be made to ensure the necessary preservation of the capacity to produce and to design the equipment using the new technical base, particularly if account is taken of the long term, when such goods will no longer be the vanguard and will become the standard of technology, and beyond this, when the producer goods of today become the durable consumer goods of tomorrow. What would be happening would be the formation of a professional culture appropriate to a modern, democratic, social-welfare country. The strategy is to preserve in Brazil the forms of work which have the highest aggregate value among those related to the incorporation of the new technical base, since in this way the country would not only cease to export high-priced jobs but also would be creating, at least in this sphere, a better-distributed income structure, which would have a dynamic effect on the internal market. In the final analysis, Brazil will also be preparing and training, from now on, a labour force capable of dealing (through production, design, programming or operation) with the future forms of material production.

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