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CO-OPERATION IN INDUSTRIAL AUTOMATION BETWEEN ARGENTINA AND BRAZIL*

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* The views expressed in this paper are those of the author and do not necessarily reflect the views of the Secretariat of UNIDO. Mention of firm names and commercial products does not imply the endorsement of the United Nations Industrial Development Organization (UNIDO). This document has not been edited.

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CONTENTS

1) INTRODUCTION

The world economy is presently going through deep changes, caused by two interrelated processes. The first is the revolution of information processing, based on electronics. In this process, electronics industrial automation equipment (EIAE) plays a major role. The second process is the integration of national economies in to regional groupings.

In the recent past Argentina and Brazil have fostered their electronics industries and they have signed an Integration Agreement, which has expanded trade of numerically-controlled machine tools (NCMT), the most widely used EIAE. Such initiatives of industrial and trade policies are exceptions in the bleakness of the industrial development of the two countries over the last decade. However, cooperation and integration in EIAE between the two countries could be greatly expanded, as this report purports to show.

The study begins by presenting the background to EIAE production and use in the two countries, reviewing their recent industrial development and, more specifically, comparing their "electronics complexes", and the role of EIAE in such group of interrelated industries (sections 2 and 3).

Section 4 analyses the production of EIAE in the two countries and section 5 narrows the focus by concentrating on numerical control (NC) units, NC machine tools and industrial robots. Both sections show that EIAE production and its costs are severely constrained by scale and learning factors, which could be alleviated by greater integration between the two countries.

Section 6 examines the diffusion of NCMTs and industrial robots - their main users, the reasons for adoption and their impact on employment. arguing that, in spite of the differences in the rate of diffusion, the patterns of use are similar enough to warrant substantial scope for cooperation between enterpries and trade unions of Argentina and Brazil.

The last section analyses the recent experiences of ccoperation between the two countries in electronics and capital goods. It argues that notwithstanding their achievements, especially as regards trade, the instruments used are insufficient to bring about the integration of EIAE the two countries need.

The report is based mainly on secondary data, published and unpublished, complemented by interviews with other researchers, industry representatives, entrepreneurs and Government officers of the two countries.

2) THE INVESTMENT ENVIRONMENT IN ARGENTINA AND BRAZIL

There are many similarities but also sharp differences in the course of development of the Argentinian and Brazilian economies. Both have a similar per capita GIP (around US$ 2500 in 1987), similar levels of industrialization (about a fourth of the GNP)and, over the last decade, both have suffered a deep crisis, as shown by negative growth rates and a sharp decline in gross capital formation (see Table 1).

The crises of the eighties in both countries are associated with a very high foreign indebtedness, extremely high rates of inflation, and a deep-seated fiscal crisis of the State. Such context, in turn, led policy-making to concentrate on foreign exchange and inflation controls, operating with a short-term horizon. Except for some sector policies (of which informatics is one of the most important),and measures related to foreign trade, in both countries there was no industrial policy. A major exception is the Integration Agreement between the two countries, discussed in more detail in the last section.

The industrialization of the two countries was based on import substitution, centered initially on non-durable consumer goods and, after the Second World War, on durable consumer industries, especially transport equipment. During the sixties the industrial rate of growth of Argentina was lower than in Brazil (see Table 1), but over the next decade, especially from the mid-seventies, such difference was sharply accentuaded by different industrial strategies. While Argentina followed a strategy of drastically reducing protection against imports, coupled to an overvaluation of the peso, Brazil deepened import substitution into capital

goods and intermediary products and, at the same time, increased exports of manufactures, especially of non-resource based products (see Table 2). Such exports relied on different comparative advantages:low wages for non-durable consumer goods such as textiles, scale economies in intermediary products and design and production capabilities geared to specific international market needs such as in capital goods and armaments (1), backed up by a complex set of fiscal incentives.

As a consequence, the crisis of the eighties, arising from the finance pattern of the two economies, finds the industry of the two countries in very different conditions - while in Argentina it is superimposed on a crisis stemming from the opening to foreign competition, with low investments in industrial capacity, in Brazil it comes when a large "package" of interrelated investments in intermediary and capital goods production is being completed, but requiring still complementary outlays by an industry which is both strongly protected and able to export.

Such differences in what may be termed "the investment climate" for the introduction of EIAE are strenghtened by the differences in size of the two countries - Brazil has a population which is about 4.5 times the Argentinian one, its GNP is about four times larger and its industrial output close to five times that of Argentina. Notwithstanding the more equitative income distribution of Argentina, the Brazilian internal market, by its sheer size alone, is more conductive to investment.

3) THE ELECTRONICS COMPLEX IN BRAZIL AND ARGENTINA - STRUCTURE AND GOVERNMENT POLICIES

The economic, social and political importance of electronics is well known . It may amount to a new Industrial Revolution, to a post-fordist techno-economic paradigm, albeit one where the role of less developed countries, including the "newly industrialized" ones is reduced, if such role is to be defined by market forces alone.(2)

For the purposes of this study, two aspects of the "electronics revolution" must be stressed: its interindustrial linkages and the role of the State.

3.1) Structural aspects

The industries producing electronic products supply different markets endowed with distinct dynamics, such as entertainment, telecommunications, data processing, and industrial and services automation. Nonetheless, the dynamics of such industries is interdependent. Such interdependence is established because they all share a common technical basis, geared to the processing of information, structured mainly by eletronic components and software. Therefore, they form an "industrial complex", a group of industries where there are strong technical linkages, economies of scope, sinergy effects and dynamic interdependencies. The convergence between some of erstwhile independent markets, such as telecomms and informatics, strenghten the interdependence.

Moreover, because of the service it provides, the processing of information, electronics technology tends to "invade" industries based on different technologies (e.g. electro-mechanical), reshaping the input/output and investment linkages between industrial complexes. Although it is a relatively small market for electronics in quantitative terms, one of the most important sectors affected in this way has been the capital goods industry, where the entry of electronics has been so deep that its present technological basis is said to consist of" mechatronics", the marriage between mechanics and electronics. Because of the role played by the capital goods industry in the economic system, such "invasion" is diffused among the purchasers of capital goods, downstream throughout the economic system.

Such process, in which the capital goods industry acts as an "intermediary" between the electronics complex and other industrial complexes and services, is greatly facilitated by geographical and technical proximities between suppliers and users, which impart a cumulative nature to the diffusion process.

As shown in Table 3, in the advanced countries the main markets of electronic products are professional ones, especially data-processing equipment, in contrast with the situation observed in Brazil and, more so, in Argentina, where consumer goods hold the lion's share of the electronics complex.

There is no systematic statistical coverage of the electronics complex (EC) in Argentina and Brazil. For Argentina the most

recent data available refer to 1983, collected by the Instituto Nacional de Estadistica y Censos (INDEC) and analysed in detail by Azpiazu, Basualdo and Nochteff (1988), from which the data below are taken. For Brazil the Secretaria Especial de Informatica (SEI) provides a yearly survey of the sectors it controls, based on information provided by enterprises. The most recent survey, SEI (1989), covers most sectors comprising the professional markets for electronics, including personal computers, but exclud the durable consumer goods industries. For the latter we used the figure provided by Tigre (1988). For comparability with the data on Argentina, we have excluded from the Brazilian figures those pertaining to software and other services.

Table 4 below presents the data available on the value of production and structure of the electronic complexes of Argentina and Brazil, with the caution due not only to normal statistical problems but also to the difficulties inherent to conversion to US dollars of currencies suffering from high rates of inflation. The comparison betwewen the two complexes is rendered more difficult because the demand for some products may vary sharply from year to year, as in the case of telecomms equipment (see Table 4), and because we have available only a single point in time for Argentina, which, to make matters worse, is not the same for which comparable information is available for Brazil.

Nonetheless, the data shown in Table 4 are useful to identify, with all preceding caveats, the great differences in size between the Argentinian and Brazilian ECs, which are greater than the differences in GNP and industrial product. Such differences are especially large for data processing equipment, which was the center of the Brazilian electronics policy (see last column of Table 4).

At the same time, the structure of the two ECs shows some important similarities, especially as regards the weight of consumer goods, which account for almost half of the EC, a proportion far superior to that prevailing in the advanced countries (3).

In both countries consumer goods (mainly TV and audio equipment) are manufactured in regions where local production enjoys several fiscal incentives, of which one of the most important are tariff exemptions. As a consequence, in both countries the manufacture of consumer goods consists mainly of the assembly of imported

parts and components, with very low integration with the rest of EC, depriving the latter of the economies of scope and sinergy effects which characterize its dynamics in the advanced countries.

The differences between the two ECs are sharper for the group of industries producing capital goods. In the first place, the Brazilian structure is heavily slanted to electronic data processing equipment -EDPE (see Table 4), a pattern more similar to that prevailing in advanced countries than the Argentinian structure, where telecomms hold a very high proportion of output. Such different profiles reflect the Government policies and the strategies of multinational enterprises in the two countries.

In the second place, the backward and forward national integration of the electronic capital goods, especially of EDPE, is substantially different. The average import coefficient of electronic capital goods in Argentina (33% of the value of production in 1983) is more than double the Brazilian coefficient for the same year (15%, according to SEI, op.cit.). For EDPE, imported inputs accounted for 47.4% of the total costs of the sector in Argentina and for 16% of the value of production in Brazil,in the same year (Azpiazu et al. 1988 and Paiva 1988). Although not strictly comparable, such data leave no doubt about the much higher degree of local backward integration of the Brazilian EDPE.

Moreover, while in Brazil the import coefficients tend first to decline and then to stabilize as the several electronic industries get established, in the Argentinian case the imports coefficients increased drastically over the years 1974/83, reflecting the "deindustrialization" policy of the period.

In both countries the subsidiaries of multinational firms tend to have higher import coefficients than the locally-owned enterprises.

As regards forward linkages, following the pattern of import substitution, the output of the two ECs is sold mainly in their national markets. In both countries exports consist mainly of EDPE, of which most are IBM's intrafirm trade. Nonetheless, there is an important difference between the Brazilian and Argentinian EDPE industries as regards exports. In Argentina, in the period

1980/1983, exports accounted for almost 90% of the sales of EDPE, while in Brazil, over the same years and considering only the foreign firms for comparability, exports represented only 17% of their billing (Paiva, 1988).

Considering the very high import coefficient of the Argentinian EDPE industry and, at the same time, the role exports play in its sales, the characterization of such industry by Azpiazu et al (1988) as an "export enclave" (p. 192) seems highly appropriate.

In other sectors too, most exports are done by subsidiaries of multinational firms. In fact, in Argentina, prior to the Informatics Policy of 1985, subsidiaries played a major role in the production of all industries composing the EC, except in durable consumer goods. The latter, however, was highly dependent on imports of technology and intermediary products. Moreover, as shown in Table 5, the participation of subsidiaries in the Argentinian EC increases substantially in the period 1978/83, except in intermediary goods, where there is a shift from local production to imports. Such features can be attributed to the "liberalization" policies of the period.

In contrast, in Brazil the containment of foreign subsidiaries to specific product lines and the occupation of new spaces by local firms has been a proeminent (and conflictive) feature of the Electronics Policy since 1977. As a result, the role of national firms is much higher than in Argentina, as shown in Table 6.

3.2) Government policies

In all countries where the electronics complex is well developed the State played a major role in such development. The State in advanced capitalist countries was responsible for structuring the electronics complex by deploying a comprehensive set of policies, embracing both supply and demand of electronic products and covering the whole spectrum of activities, from R&D to marketing, through the use of the full panoply of industrial policy measures which reduce both risks and costs to private firms - from grants to research activities to protection in the internal market (inclusive by heavy State purchases) and export incentives. Moreover, in such countries the State has also promoted the diffusion of electronics by policies which reduced the costs of adopting such technologies, especially in the capital goods

industry - e.g. for the adoption of numerical control in the machine-tools industry.

The comprehensiveness and persistence of such State intervention in the advanced countries, a major element in the development of their electronics complex in an international scale, stands in stark contrast with the limited policies implemented in Brazil and Argentina for their local electronic complexes.

The electronics policy of Argentina and Brazil have been extensively described in the literature (3) and space limitations preclude detailing them here, where we shall highlight only some of their structural features:

i) The "industrial complex" approach

In Brazil a comprehensive approach to the policy, embracing the whole EC developed gradually. In 1977, when the policy started, it embraced minicomputers and their peripherals only. However, already in 1979, when SEI was created, its mandate covered all branches of the EC. Actual policies for the different sectors were then progressively defined. For instance, general policy directives for industrial automation were established in 1981 and afterwards, such directives were specified for numerical control (NC) in 1981, for process controllers (PC) and digital systems of distributed systems (DSDS) in 1982 and for computer aided design (CAD) and robots in 1984.

The Informatics Law (7232) of 1984 reinforced the "industrial complex approach" by covering "all activities linked to the rational and systematic treatment of information" (art. 3 of the Law).

Nonetheless, SEI has not been able to implement such integration. In practice, durable consumer goods production, and telecommunications equipment have remained outside the pail of the Informatics policy, reducing its efficacy substantially. The first industry benefits from special fiscal incentives wich stimulate the import of technology and components while the latter favours joint-ventures between local and foreign enterprises-policies wich differ sharply from the Informatics policy.

Furthermore the policy has concentrated on the supply of goods and services. Diffusion measures were limited to credits to the purchase of EIAE. However, such credits were not especially designed to foster the diffusion of EIAE.

In Argentina, the policy proposed in 1984 by the National Informatics Commission had, from the outset, an integrated view of the electronics complex. However, the first policy measures (Resolution 44/85) of the Secretaria de Industria were directed mainly to EDPE. A more recent and comprehensive Decree (652/86) provides incentives for most segments of the EC but does not include scientific and medical instruments in the list of sectors it benefits and does not cover the production of durable consumer goods, which benefit from a different set of incentives, of regional scope. Moreover, similarly to Brazil, the policy for telecommunications equipments has not been integrated with the other electronics policies.As in Brazil, there was no "diffusion policy" except for limited credits for acquisition of capital goods.

ii) Local production and technology

Following the tradition of import substitution, the electronics policies in the two countries have fostered local production of finished goods and their components, but they departed from that model (and more so from the liberal policies followed by Argentina in the late seventies) by establishing as a major objective the development of a national technological capability.

Such capability was to be achieved by increasing the State outlays for human resources development in fields related to electronics, by the establishment by the State of research institutes and, most importantly, by making the granting of the policy incentives to enterprises conditional to their investment in technological capability.

In both countries the fiscal crisis, compounded by the low priority given by policy-makers to local technological development, have limited considerably the scope of State expenditures for such purpose. As regards enterprises, the evidence available for Brazil shows that local firms have not only developed a technological capability in production but have

also advanced substantially in design skills, beyond the range required for import substitution and warranted by licensing foreign technology. In Argentina, the projects under the informatics policy were started, at the earliest, in 1986, but a recent appraisal (Azpiazu, Basualdo and Nochteff 1989) shows evidence of considerable design and production learning in the enterprises, resulting from their policy commitments.

iii) Local and foreign enterprises

Another departure the electronics policies introduced in the previous patterns of industrial policy of the two countries is the preferential treatment given to locally owned enterprises. This was due not only to concerns over national autonomy, considering the strategic role played by the EC, but also to the realization that the rationale of multinational firms would prevent them from making substantive investments in local technological capability.

Therefore, in Brazil, markets where there are national firms capable of supplying them are reserved for such firms. The concept of "national firm" involves the control of decisions and of technology besides equity, which must be at least 70% local. Thus, joint-ventures are allowed, but the foreign partner cannot be the supplier of technology, in order to preserve technological autonomy. Contrary to this approach, in telecomms the foreign subsidiaries supplying the Brazilian market were obliged to form joint ventures with local firms, retaining the de facto control of the new enterprise.

National firms may use licensed technology, provided there are no locally developed alternatives and, as mentioned above, they must commit themselves to develop the next generation of products locally.

It is important to stress that foreign subsidiaries also enjoy a very high level of protection in the Brazilian market.In fact, their number has increased after the inception of the policy.

In Argentina, although the bidding for fiscal incentives under Resolution SI 44/85 was conditional to the enterprises being nationally owned too, the definition of "national" required only that more than 50% of the capital of the enterprise was local. Two of the thirteen projects finally approved involved joint-ventures between national and multinational enterprises.

iv) Policy instruments,

In contrast to the similarities observed above, the instruments used for the EC policies are substantially different. In Brazil a National Council for Informatics and Automation, composed by State ministers and industry and academia representatives, is responsible for the electronics policy, which is embodied in a three-year Plan, which must be approved by Congress.

SEI acts as the Executive-Secretariat of the Council and it must approve the projects for producing the goods under its mandate and the imports of electronic products. The Informatics Law provides some fiscal incentives for the sector, but the value of such incentives, so far, has been very limited (Paiva 1988). Credit by the Federal Government development agencies, a traditional instrument of Brazilian industrial policy was, until recently, also very restricted. Moreover, the three Government banks which jointly own the only State enterprise of the sector, a producer of EDPE, have kept it chronically undercapitalized, despite the role played by the latter as technological leader of the industry. Finally, State purchases, which account for a substantial part of the demand for electronic products, have not been used convergently with other policy instruments as means for achieving industrial and technological objectives.

In spite of the shortcomings above mentioned, the electronics policy in Brazil has more instruments than its Argentinian counterpart. In Argentina the proposal of institutionalizing a National Commission for Informatics, Telecommunications and Electronics was not implemented and the EC policy has been carried out, in practice, by the Secretaria de Industria y Comercio with the help of the Secretaria de Ciencia y Tecnica. The main instrument used by the former has been public biddings for fiscal incentives, which, first, involved tariffs and VAT but later were reduced to the former. Tariffs are used both to foster local production, subject to a gradual decrease of protection and to reduce the cost of importing parts and components.

In the first round of bidding most products were EDPE. After a protracted period of negotiation, thirteen projects were approved, of which only one is for industrial automation - the development of a logically programable controller (LPC) by a firm belonging to one of the main producers of custom-built capital

goods, which uses the LPC for its main line of production.

4) ELECTRONIC INDUSTRIAL AUTOMATION EQUIPMENT (EIAE)

The industry producing EIAE in the two countries is substantially different. To some extent such difference can be ascribed to the divergence in the pace of industrial investment, but a considerable part is to be explained by the electronics policies previously described.

In Brazil, the local production of EIAE is a direct consequence of the reserved market policy, which was regulated in 1981 for numerical control (NC), programmable controllers (PC) and digital systems of distributed control (DSDC) in 1982, and robotics and computer aided design (CAD) in 1984.

In 1988 SEI surveyed 74 firms producing equipments for industrial automation, of which 72 were nationally owned. The two foreign owned firms produced only 0.3% of the output of the sector in value terms. Previous to the 1984 Informatics Law the Brazilian market was supplied mainly by imports and by a small local production by foreign subsidiaries. Some of the latter, such as Siemens in NC, preferred to continue to service the market indirectly, through licensing.

Despite the industrial crisis, the production of EIAE increased 55% between 1986 and 1988, reaching US$ 309 millions in the latter year (see Table 4). Local content of production is high, with imports accounting for only 8% of the value of production.

The sector employs 7500 people, of which 30% are university trained. Twenty per cent of total personnel and almost 60% of university-trained employees are used for product development activities. In 1987 the firms invested about 8% of their sales value in R&D, a percentage reduced to about 6% in 1988, a year of slower growth. The leaders of the sector in terms of sales, six firms accounting for 47% of total sales, are the heaviest spenders in R&D.

The products of the industry can be divided in two groups, the

first composed of equipments for process control and the second of goods for the automation of manufacture. In 1988 the first group produced 72% of the total value of the industry and the second 27%, the balance being held by the incipient autonotive electronics.

Table 7 presents the main products used for process control, of which PCs and DSDCs are the most important.

Although there are about 20 firms producing PCs, the market is heavily concentrated around three firms, which held over two thirds of the total sales in 1988. Two of such firms use licensed technology while the third firm (second in sales value, holding 18% of the market) uses its own technology. Following a pattern observed in other segments of the EIAE industry, the latter produces simpler and less expensive products than the former two.

The main users of PCs in the period 1983/86 were industries producing automotive equipment, plastics and rubber goods and electrical and non-electrical machinery, including electronics, i.e. industries operating with discontinuous processes. Continuous process industries, such as chemical and petrochemical, steel and metallurgy, although heavy users of PCs (especially of large units) are switching their demand to DSDC (S5p 11989).

Local production of DSDC took off in 1985, when 20 systems were produced, against 3 in 1984. Presently, there are eight suppliers but three of them sold 97% of the total value in 1988, with the leading enterprise holding 58% of the market. (SEI 1989). The three companies operate with licensed technology. DSDCs were purchased mainly for projects of modernization and expansion of firms producing petrochemicals, paper and cellulosis products (S5p 11989).

Table 7 presents data on the main products used for manufacture automation. NCs (and the machine tools they control) and robots are treated in more detail in section 5.

Exports of Brazilian produced EIAE are very limited - US$ 0.6 and 2.5 millions in 1987 and 1988, respectively. Most of them (64% in 1987 and 81% in 1988) consist of CNCs exported to Argentina under

the Integration Agreement discussed in more detail later on.

The information about EIAE in Argentina is older and less precise. According to Azpiazu et al. 1988, in 1983 there were 37 firms producing electronic products for industrial automation, instruments and medical equipment. Their total production amounted to US$ 36.6 millions, 17% below the level reached in 1980, although two firms had entered the market since the latter year.

As a result of the industrial policy followed in the period, a substantial share of the sales of such firms consisted of goods produced elsewhere, especially abroad - 30.8%. Local backward integration of production was also limited and apparently decreasing, since national inputs accounted for a third of total costs in 1978 and for 18% in 1983. Ownership of the industry was drastically changed too - while in 1978 foreign firms accounted for only 10% of the value of production, five years later such share had risen to 61%.

About 11% of the total number of employees were university-trained in 1983. A year later it was estimated that 9% of the total were employed in R&D activities. At least three firms of the sector reported having licensing contracts with foreign firms, of which half were with members of the same group.

It is worth stressing that the data above refer to a sector comprising a wider variety of products, such as instruments than those seen above for Brazil.

More specifically, for process control equipment, Soifer 1986 estimates that the Argentinian market for process control equipment was around US$ 15 million dollars per year, of which between a half and two thirds were for distributed control. The size of the market does not seem to have changed between 1978 and 1985.

Imports supply most of the demand, with local firms concentrating on small products and systems. As mentioned above, following the incentives scheme of the Electronics Policy, a firm has started to produce programmable controllers, to be used mainly with the custom-built capital goods its parent company produces.

As regards other industrial automation equipment, no information is available, except for NC, discussed below.

5) NUMERICAL CONTROL AND ROBOTS

In this section we examine, first, the production of numerical control units, then the supply of NC-controlled machine tools (NCMT) and, finally, the robots supply. There does not seem to be any flexible manufacturing system production in the two countries.

5.1) Numerical control units

The development of NC in Brazil was strongly affected by the Electronics Policy, as described above. Prior to the enactment of market reserve regulations in 1982, most locally produced NCMT used imported controls. Siemens had started local manufacture of CNC units in 1979, but its product was already obsolete. A year later Heidenhain's local subsidiary anounced plans to manufacture two models, suited, however, to milling machines only. A local company had started marketing a CNC unit it had developed, but with little success and then entered a joint-venture with General Electric, which, however, soon withdrew from the partnership (Laplane 1988).

With the curtailment of imports and the reserve market policies, Siemens and Heidenhain chose to operate in Brazil via licensing and, presently, the market is supplied by seven firms.

There are substantial discrepancies between the figures provided by SEI and SOBRACON (a manufacturers' association) for the number and value of production of NC units in the recent past, as can be observed in Table 8 . Nonetheless, local production is around a thousand units per year with a total value of around US$ 20 millions, a sizable market in international terms, similar to the French market, according to the data provided by Laplane 1988.In terms of units produced the growth of the market has been impressive between 1984 and 1987 - 5.5 times according to SEI and 4.5 times according to SOBRACON (see Table 8).

A major characteristic of the Brazilian supply of NC is its segmentation. Of the seven suppliers, three are captive to local producers of machine tools - one to the leader of the industry in Brazil and a large producer in international terms, manufacturing over 3000 machine tools per year; the second to a medium-sized producer of grinding machines and the third operating under an OEM agreement with one of the main producers of special machine tools, a subsidiary of a German firm. The second firm has developed its products in-house while the other two operate with foreign technology licenses.

Within the other group of producers, composed of merchant suppliers, competition, at the begining was virtually non-existant, since the two first-comers operated with licenses from Siemens and Heidenhain and supplied different markets. Given the specificity of Heidenhain's technology, suited to milling machines only, this left Siemens' licensee, a firm belonging to a large group producing metal products and machinery, with the virtual monopoly of the merchant market, supplying relatively complex and very expensive NCs.

Such monopoly was successfully challenged in 1984 by a relatively small electronics firm, which presented a much simpler and less expensive system, based on the desing capabilities of the owners, developed while working for a foreign firm.

Its products have proved to be very suited to the Brazilian market conditions and it has become the leading producer in terms of units. As a result, Siemens' licensee, which is still the main firm in terms of sales value, has introduced simpler models. Since the other firm is upgrading its product range, competition is increasing in the middle range of the market.

In the higher end of the market, competition has also increased. In 1986 Heidenhain's licensee dropped the contract and started to manufacture a NC unit that can be used to control both NCMTs and industrial robots. Last year, a leading firm in the PCs market started producing a sophisticated CNC unit based on PC technology.

Therefore, the Brazilian producers of NC units can be grouped

according to their strategies relating either to their marketing (captive or merchant) or to their source of technology (locally developed or imported). In Table 9 we present a combination of the two in matrix-form, using SEI's (1989) data for 1988, which are presented broken down by firm.

According to our estimates, merchant supply, which plays a basic role in the diffusion of electronics technology within the machine tool industry,is responsible for over 80% of the total number of machines produced and two-thirds of the value of production of the sector. Of such production almost 60% of the units were manufactured with local technology, corresponding to 31% of their total value.

Still looking at the sector from the point of view of local technological development, the same Table shows that over half of the NC units were internally designed. Since such products tend to be simpler than the licensed units, their share of the value of production is only a fifth of the total.

Exports of NC units have been limited - US$ 0.4 and US$ 2 millions in 1987 and 1988, respectively. Such exports, of products under license of Siemens, go to Argentina, where they are coupled to machine tools locally produced and afterwards exported back to Brazil under the recent Integration Agreement between the two countries, discussed in more detail below.

In an interview done for this study, executives of a leading producer of NCMT in Argentina, which use NCs made in developed countries for the machines which go to other markets, remarked the very high cost of the Brazilian-made NCs, which, according to them, cost about four times the price of Japanese NCs.

Brazilian users have also complained about the difficulties of importing NCs and the high cost of local substitutes. Nonetheless, in a recent interview, the President of the Machine Tools Producers Association (ABIMAQ) has aknowledged that import restrictions to products which have no national similar had been lifted and that the price differential vis a vis foreign products had fallen, from five to six times to two to three times, still a very high differential.

International price comparisons for products which have so many characteristics as NC units are intrinsically difficult. In the Brazilian case such difficulties are compounded by the foreign exchange rate limitations previously mentioned. Part of such problems can be met by comparing prices of equivalent products, in Brazil and abroad, a procedure facilitated by the use of licensing.

SEI followed such a procedure in an unpublished study, where it shows that the FOB prices of Brazilian-made NCs dropped sharply from 1983 to 1986 and increased again in 1987, due to the introduction of new models and exchange fluctuations, such as the yen valorization.

Comparing the prices of Brazilian-made products with their equivalents abroad, the differential drops from 1.94 times in 1983 to 1.63 in 1987. The price differentials are not the same for products locally designed and licensed: the former start the period costing 1.46 times their foreign equivalent and end up costing the same, while the others begin with a price 2.24 times higher and maintain such differential, increasing it in the last year to 2.72.

Several factors explain the high cost of Brazilian NCs. In the first place, the scale of production is small, compared to international standards, burdening not only the fixed cost but also the cost of purchasing components, locally and abroad.

Although the world leader of the industry, Fanuc, is reported to manufacture about 4000 units per month (Chudnovsky 1988), other important international suppliers in the U.S. and Europe produce about 1000 units per year. This order of magnitude was reported as desired by the Brazilian manufacturers in interviews with Laplane (1988). Presently, the two largest merchant suppliers produce in the range of 350 to 450 units per year.

In the second place, there is the high cost of components, both local and imported. The former are expensive because they are produced in small scale too and the latter are burdened by diseconomies of small batches purchases.

Thirdly, local production of NC is still in its infancy stage,

with all the general inefficiencies that go with that age, which, as the data above indicate, the Brazilian industry seems to be going through quickly.

Finally, it is probable that the limited competition established by the combination of import restrictions and market segmentation previously analysed, has warranted high mark-ups for the locally established producers.

Both local and foreign users consider the quality of the products good and the former are satisfyed with the technical assistance received (Laplane 1988). Such factors, coupled to the mastery of design skills and the reduction in prices, indicate that a strong learning process is under way in the Brazilian NC industry.

Therefore, any assessment of the policy for the sector is highly dependent on the time horizon adopted. If we add the difficulties of estimating and assessing the importance of foreign exchange savings at a time of exchange restrictions and the role played by the increase in national autonomy, we can conclude that there is no "value-free" assessment of the policy for NC.

In Argentina, so far there is no local production of NCs, although a local firm has recently presented a project of NC assembly under the fiscal incentives scheme for electronics. No details could be obtained about such project. The local producers of NCMT use, as indicated above, NC units imported from the advanced countries, especially Japan, except when they sell to the Brazilian market, when they either sell the machine without the NC unit,which then is added up in Brazil, or they import the NC from Brazil and then export the whole system back.

5.2) NC Machine Tools

In both countries the local production of machine tools starts at the end of the thirties, with enterpises established by immigrants, mostly from Italy, often as repair shops which, then, moved into production, based on reverse engineering and protected by foreign exchange restrictions.

Over the next three decades the two industries expanded

considerably, accumulating substantial productive and design capacity, stimulated by the import-substitution investments of other branches (especially durable consumer goods)and protected against imports by tariffs and administrative controls.

In the mid-seventies, however, in Argentina, the combination of slower industrial growth and sudden and drastic reduction of protection, brought about a severe contraction of the production of machine tools. In fact, as shown in Table 10 the number of machine tools produced in 1985 was a 14% of the output of 1973.

Over the recent years, output has expanded substantially, based mainly on exports, which accounted for two thirds of production in 1988 (see Table 11). The sharp increase in exports in 1987/88 is a result of the Integration Agreement with Brazil, discussed in more detail below.

However, in 1989, the continuing decline of internal sales was not compensated by exports, which fell 12% in the first semester compared to the same period of the year before. As a result, production of machine tools in Argentina seems to be declining with the firms still active operating only at half capacity (AAAFMHA, 1989).

Imports play a major role in the supply of the local market - 74% in 1988. The average value of machines purchased, shows a rising trend suggesting that demand for more complex machines is increasing.

Compared to the Argentinian industry, Brazilian machine tool production is much larger - an order of six times in terms of number of machines and about ten times in terms of value of production (measured in US$, with all caveats). Such differences are far greater than the differences in terms of total manufacturing production and they reflect the different industrial strategies and policies the two countries have followed since the mid-seventies.

In Brazil, the industry expanded throughout the seventies, reaching 73 thousand machines at the end of the decade, which made it a significant producer in international terms. The crisis of the eighties, which led to a sharp contraction of the internal

market and, concomitantly, of the main export markets (especially Mexico), led to a drastic reduction in output, of which the industry has not recovered yet in terms of number of machines. As in Argentina, the lowest point was reached in 1985, with only 30% of the level of production of 1979. Similarly to what happened south of the border, in the recent past production recovered partially, but still at levels well below of those prevailing during the seventies.

However, as shown in Table 12, the Brazilian machine tool industry differs substantially from its Argentinian counterpart in terms of "openness" - both import and export coefficients are much lower than the Argentinian ones, reflecting the greater protectionism of the Brazilian industrial policy. The latter may also partly explain the greater average value of the Brazilian machines, besides differences in complexity of the machines demanded in the two markets. The increase in the import coefficient in 1988 (to 25% of apparent consumption) can be ascribed mainly to the liberalization of imports in that year. Exports consist mainly of relatively simple machines, sold mainly in the Latin American markets, especially Mexico, although the last market has reduced its purchases of Brazilian machine tools substantially since 1982.

In Brazil we can distinguish three broad groups of enterprises producing machine tools, according to the type of product they manufacture and ownership of the firm.

The first group is composed by about a dozen of large and medium enterprises, subsidiaries of foreign firms, most of them German, which were attracted by the Brazilian market, especially by the automobile industry. Such firms produce transfer lines, special production machines, NC lathes, machining centres, NC boring machines, and high performance presses, covering a wide range of complex machines. They operate with the technology supplied by the parent house, but recently they were obliged to increase their local technological capability in order to adapt their products to the local supply of electronic components, especially the CNC units. The producer of NC units which operates under an OEM arrangement mentioned above, is a captive supplier of one of the subsidiaries.

Their main markets are the automobile industry (assemblers and autoparts), aeronautics and the rest of the machine tool

industry. There is no counterpart of this group in Argentina, presumably because the market there is much smaller, especially the automobile industry, which produces about a fifth of the Brazilian industry.

The leading Brazilian-owned firms can be considered a second group. As in the first group, it is composed by a dozen of large and medium-sized firms. In fact, within this group we find the overall leader of the industry, and a large producer in international terms, which, in 1985, had sales over US$ 43 million (about 13% of the industry's) and employed more than 3000 people, producing more than 3000 machines per year.

However, differently from the first group, the strenght of such firms is on conventional machine tools and only recently they have moved into NC, which the leader produces for its own use, being the largest captive supplier of NC units. Although it is a small firm in size, we may place in this group, for its technological capability, the third captive producer of NC units, which manufactures grinding machines.

The two groups of firms produced in 1985 about 44% of the total value manufactured by the industry. The concentration is proportionately larger if we consider only the five largest producers (of which three are subsidiaries) since they account for a third of the industry's value of production.

Finally, there is a third group, formed by some eighty medium and small-sized Brazilian owned enterprises employing less than 500 people each, which manufacture universal conventional machine tools. Such firms were probably the most affected by the crisis in terms of sales and technological capability and are finding updating, even at the level of introducing NCMT in their production process, difficult.

In Argentina, Chudnovsky and Groisman 1987 identify four broad groups of enterprises in terms of sales and technological level. In the first group there are three enterprises which are producing NCMT routinely - lathes, milling machines and machining centres. They operate with foreign licenses but have also a strong design capability and, in 1987, had ongoing investments for expanding capacity. Compared with the Brazilian leaders, the Argentinian main firms are small-none of them having more than 200 employers.

The second group is composed of three firms producing deformation machines (especially presses), a sector where technical progress has been slower than in metal-cutting machines, and two producers of lathes, one of which produces special equipment. The later two are starting to produce NC machines but not regularly yet.

Some thirty firms composed the third group, most of them small firms, which had been deeply affected by the crisis in production and technological capacity and were, in 1987, still trying to recover some of the lost ground.

Finally, the last group was composed by a great number of small firms which operated mostly as subcontractors for relatively simple tasks and as repair-shops, with very limited equipment and technological capability.

The same authors report that the 1984 census showed that the four largest establishments accounted for a third of the total value of production of the sector producing metal-and wood-working machinery. Concentration, however, is much greater at specific product levels, especially for more complex products. Thus, in 1986, for lathes, two enterprises out of 12 accounted for 57% of the total production and 90% of NC lathes. Similarly, for milling machines, three firms out of 10 produced 44% of the value and only one supplied NC machines. The most extreme case was that of machining centres, which were produced by only one enterprise.

With due allowance for the differences in size (of market and of enterprises) there seem to be substantial similarities in the process of adaptation to the technological change of the machine tool industry between the two first groups of Argentinian producers and the last two groups of Brazil. However, such differences make the latter more likely to succeed than the former.

In both countries the industry presents a picture of concentration and technological heterogeneity, which was worsened by the crisis. Given the profound technological transformation the machine tool industry is undergoing, arising especially from the introduction of electronics, the crisis has also widened the

technological gap which separates the two industries from their counterparts in advanced industrialized countries, both in terms of best and average practices.

The structural differences noted above are compounded by Government policies, especially as regards credit and fiscal incentives to exports. As regards the former, the Brazilian industry has benefited from the relatively cheap credit of the National Development Bank (BNDES) for its own investment and the credit lines of BNDES' subsidiary (FINAME) for its sales, while in Argentina there is no equivalent support. For exports, both industries had the benefit of several fiscal incentives (not specific to the MT industry) but in both countries the recently empowered Government have suspended such incentives as part of their public deficit control. Given the role exports play in the Argentinian MT industry, such measures, if continued, make its prospects dimmer.

Given the context above described, we can now turn to the production of NCMT in the two countries in more detail.

The introduction of NCMT in the Argentinian and Brazilian economies occurs mainly in the eighties. In Brazil, until 1972 there were only three NCMTs, imported by firms producing automobiles and autoparts. Local production begun in 1975 by the industry leader with a conventional lathe adapted to use an imported NC. In 1978 a German subsidiary firm begun production of machining centres. By the end of the decade (1979) there were 406 NCMTs, of which 110 were locally produced (Fleury 1988).

In Argentina, in 1972 there were at least 13 NCMTs, all imported, and by 1981 the total stock had increased to about 350 units (compared to 986 in Brazil), most of which imported. Local production started in 1979 and by 1981 about a dozen units (lathes) had been manufactured. (Chudnovsky 1985).

Presently, it is estimated that the stock of NCMT in Brazil, at the end of 1987 was 4176 to which should be added 742 machines locally produced in 1988 (import data were not available). With the internal recession, imports restrictions and the increase of local production, imports of NCMT were substantially reduced, so that locally produced machines accounted for 70% of the total stock and the import coefficient for the years 1985/87 was 17%

(see Table 13). Over the recent years imports consisted mainly of relatively cheap Argentinian NCMT (mainly lathes) (see below), spark-erosion machines for tool-making and machines for quality control labs, the latter two imported mainly by NCMT producers (IPT 1985).

In Argentina it is estimated that the total stock at the end of 1988 was circa 800 units (personal information, by E. Cohen), of which we estimate about 67% were locally produced (see Table 14). Over the period 1985/87 the bulk of imports of NCMT was almost evenly divided between lathes (40%) and milling machines (37%).

In Brazil, over the period 1986/88, NCMTs accounted for 2.8% of the total number of machine tools produced and 38% of the value of production. In Argentina, in the same period, but taking into account only the NC lathes and machining centres, the percentages were, respectively, 1.5 and 20. Such shares of production are well below those observed for more industrialized countries - in Japan,in 1985,NC machine tools accounted for two-thirds of the production value of MT and in other countries their share was around 50% (Chudnovsky and Groisman 1987).

In both countries, NCMT production is concentrated on lathes and machining centres, which, in Brazil, in 1987 accounted for 74 and 78% of the total number and value of production of NCMT. In Argentina such percentages are probably higher.

In Brazil, there are 8 enterprises supplying 38 models of machining centres, 4 suppliers of NC lathes, offering 45 models, 8 producers of milling machines, with 10 models , two producers of horizontal reamer boring machines, with 5 models and five producers of grinding machines offering 16 models (ABIMAQ 1989).

The foreign subsidiaries dominate the supply of machining centres and divide the market of NC lathes with the two leading Brazilian-owned firms. The other products are supplied mainly by local firms.

In Argentina, as mentioned above, machining centres are produced by only one firm, which also supplies NC lathes, competing essentially with only another producer. A third firm produces NC milling machines. All the firms are locally owned.

Brazilian production of NCMT is directed to its own market but exports have taken up an increasing share of the Argentinian production, especially in the later years, after the signature of the Integration Agreement between the two countries.

While in 1985 only one NC lathe (data refer to lathes only) was exported from Argentina, in 1988, 77 machines were sold abroad totaling circa US$ 10 millions, accounting for 86% of the total value of production of NCMTs. In the last year they accounted for about 30% of total machine tools exports from Argentina. Practically all NC lathes exports went to Brazil where they now occupy a significant portion of the market-approximately 14% of the number of NC lathes manufactured in Brazil and about 7% of the Brazilian industry sales in 1988. One of the Argentinian NCMT producers has set up a subsidiary in Brazil, where it manufactures special machines and transfer lines, acts as sales office for the parent-company.

In both countries NCMTs tend to cost substantially more than in the international market. For Argentina we have a detailed comparison, model by model, for NC lathes (two axis), vertical NC milling machines and vertical and horizontal machining centres, in Chudnovsky and Groisman 1987. Compared to prices in the U.S. market of products offered by distributors of goods originated in Japan, South Korea and Taiwan, Argentinian NCMTs tend to cost twice more (milling machines and lathes) and thrice more (machining centres). If compared to the price offered by the same distributors for exports from the U.S., the price differential increases to three and four times, respectively. South Korean machining centre prices are also between a half and a third of the Argentinian prices. However, when compared to Japanese prices, the difference to the Argentinian price is much smaller - e.g. 25% for machining centres. Moreover, Italian and Spanish prices tend to be higher than those quoted by Argentinian producers.

There is no equivalent study available for Brazil. However, users of NCMTs have often complained that the locally produced machines also cost around three times the imported equivalent. It is worthwhile noticing that the average price of Brazilian NCMT in 1988 (US4 301.3 thousand) is almost two-and a half times greater than the Argentinian average value of production for that year. The Brazilian products seem to be more complex than the

Argentinian ones, but further research is needed to ascertain the causes of such price differences.

Low scales of production are probably one cause of the high cost of NCMT in the two countries. If we take the estimate by the Boston Consulting Group (quoted by Chudnovsky 1988) that 400 units per year are necessary for an economic production,of NC lathes,it is clear from the information above that production levels in Brazil are well below that minimum and even more so in Argentina.

Interviews with machine-tool producers recently reported (Laplane 1989) show that such producers consider the local supply for raw materials and components as one of the major reasons for their high costs, emphasizing the scale of production of components. Contrary to suggestions advanced in the literature, the enterprises do not consider their high degree of vertical integration as an important cause of higher costs.

More specifically, NCMT producers have often complained about the high cost of the electronics components. As we saw above, NC units in Brazil cost substantially more than abroad and NCMT usually incorporate other electronic components, such as programmable logic controllers for materials handling, engine drives and interfaces. In Laplane (1989) it is reported that the Brazilian MT firms estimated that the local electronic components costed 34% more than the international price.

In Argentina such components are imported, paying the lowest tariff, but, under the terms of the Integration Agreement, they cannot be exported to Brazil. Argentinian NCMT producers must either export the machine without the NC unit, which is then added up in Brazil, or import the NC unit from Brazil, couple it to the Argentinian machine and, then, export the complete system to Brazil. As we have seem above, such imports from Brazil have increased substantially, totalling US$ 2 millions in 1988, equivalent to 22% of Argentinian NC lathes exports to Brazil.

For the foreign subsidiaries operating in Brazil the restrictions on imports of electronic components have implied extra costs because they have to adapt the machine, designed in Germany for the German supply of components, to Brazilian conditions. In turn, this has obliged the subsidiaries to go through a learning

process, embedded in the engineers locally employed, which would not have happened under their previous strategy of total technological dependence on their parent companies (Erber 1982).

Another major source of high costs in Brazil, as reported in Laplane 1989, are castings, which are locally priced 50% above the international cost. In contrast, in Argentina this cost, a key item in the production of machine tools, is similar to the international price (Chudnovsky 1988).

Further research on the differences above mentioned and on the role played by such factors as the high financial costs prevailing in the two countries and the weight of monopoly profits deriving from protection against imports, would be convenient for policy-making purposes,especially now, when the two countries are going through a period of revision of their industrial policies.

5.3) Industrial robots

The situation of industrial robots (IRs) in the two countries is very similar to that previously described for NC units.

IRs were first introduced in Brazil in 1983, imported by the automobile industry. At the end of the next year 26 multifunctional programmable IRs had been imported (of which 21 for the automotive industry) and demand projections were optimistic - it was expected that investment in IRs would total about US$ 80 million between 1986 and 1990, with about 500 IRs sold at the end of the period (4).

Thus, after SEI, in December 1984, invited locally owned firms to submit their projects to produce IRs, more than 20 proposals were submitted in the next year. SEI approved seven manufacturing projects, three based on licenses from abroad, for multifunctional IRs, and four based on local designs, for simpler IRs. Nine projects of product development were also authorized, two of which for the electronic control system.

With the reduction of investments, especially in automotive industry, demand has increased much less than it was expected. Only 73 IRs were sold in the period 1986/88, raising the

estimated stock in Brazil to 99 IRs (SOBRACON 1989). According to the data provided by SEI 1989, the producers of multifunctional robots sold 35 units over the period 1986/88, most of them in 1987. As shown in the same Table, sales have sharply declined next year and SOBRACON'estimates for 1989 put them at approximately the same level of 1988 (14 units at US$ 2.1 millions).

Similary to the NC units industry, the production of IRs is highly segmented. A first group of enterprises produce multifunctional IRs based on foreign licensing. One of the four originally approved producers has left the market and competition between the remaining three is limited because of differences in the products they supply. For instance, only one producer has a model suited to spot welding, the main application of IR in Brazil.

As a consequence of this combination of limited demand and product specializaton, sales have been very irregular. The above mentioned producer, sold 23 units in 1987 and none in 1988. Of the other two, one sold its first seven units last year, while the third sold two units in 1987 and two more in 1988.

A second group of producers, of about eight potential suppliers of IRs, developed their products locally. Such products are much simpler than those manufactured under license (e.g. with less degrees of freedom and more limited lifting capacity), suited mainly to manipulation activities, such as pick-and-place, machine loading and material handling.

About half of such firms have followed a strategy of designing standard IRs, while the other half have preferred to supply custom-made equipment, which has the advantages of reducing risks and increasing joint development of application technology by user and producer. Although the latter strategy seems to be marginally more successful, only a small number of firms of the second group actually implemented their product development programmes and have been able to sell IRs.

Although two firms had projects approved by SEI to supply electronic and mechanic components,the imported content of the locally manufactured IRs is still high and tends to remain so because of the small scale of assembly.

Licensors of technology have provided their Brazilian counterparts with training for assembly and quality control as well as support for the development of local sourcing. Licensees have concentrated their design efforts on minor adaptations, mostly related to local sourcing. The firms which did not use licensing relied mainly on the technological capabilities developed in other lines of production.

Given that IRs stand at the interface between the electromechanic complex and related metal-working activities and the electronics complex, it is not suprising that entry into IR production comes from the two sides - IR manufacture is part of the activities of firms producing other EAIE, such as process control systems and NC units or of firms with a large tradition of producing capital goods, defense equipment and forged and cast metal-products. Some of those firms use the IRs they manufacture for their other lines of production in a pattern similar to that observed in Argentina for process control equipment (see above).

According to the interviews reported in Laplane 1988, financial resources for IR operations come either from the parent companies or from other product lines. The bulk of investment is directed to product development and to training, since application technology development, engineering services, technical assistance and marketing activities are becoming critical at a time of limited demand. Engineers and highly skilled technicians are the majority of the workforce and firms are investing heavily in training, in-house and abroad. In fact, Laplane comments that "producer firms increasingly act more like engineering consultants than as IR manufacturers, since application technology development is essential to the growth of IR sales. This approach has been followed both by licensee firms and by producers which use their own technology, as a response to negative market conditions" (Laplane 1988 p. 224).

Although IR production is not scale-intensive, even in the developed countries, the differences observed between the output of firms in Brazil and abroad is enormous. Hitachi and ASEA manufacture about a thousand units of their licensed models yearly, while their Brazilian licensees have produced, in two years, respectively, 23 and 7 units.

Although we have not available price comparisons between Brazilian-made products and their imported equivalent, in all likelihood the former are considerably more expensive, especially if we add to the scale-effect the costs of learning and the investments in manufacturing, design and training which the Brazilian firms are presently making.

The reduction of such fixed costs depends mostly on demand conditions, but partnerships may be an important element to reduce the cost of IRs. Several partnerships were established at the time projects were submitted to SEI to combine financial resources and technical expertise arising from the two technical bases which underly the design and production of IRs. In fact, most partnerships combined two firms, one with electronics experience and the other with a tradition in mechanic or metallurgical activities. More recently, joint product development programmes have been established by IR producers to develop new models. Some of these were established between firms relying on licenses and firms which have designed their own products, which may lead to an important process of technological cross-fertilization.

Beside their effect on cost reduction and technical learning, the partnerships above mentioned, which involve some large industrial groups (the parents of the IR producers), may have an important paradigmatic effect on cooperation between producers of capital goods and of electronic products, which, so far, have resisted the Government attempts to induce cooperation (e.g. in supermini computers). Since cooperation, within the electronics complex and between the complex and other industries which interface it, seems to be essential if the Brazilian industry is to overcome size limitations in terms of R&D and production, the experience of the IR industry is of crucial importance.

In Argentina there is no local production of IRs. The latest estimate of the stock of IRs in 1988 (E. Cohen, personal information) was of 14 IRs, all of them imported. Local production, was limited to a prototype for training, which had dimensions and lifting capacity unsuited to industrial applications (ibid).

6) THE USE AND IMPACTS OF NCMTs AND ROBOTS

The use of NCMTs and IRs in Argentina and Brazil is still very limited and there are important differences between the rates of diffusion of the two types of equipment in the two countries. Howeverthe patterns of diffusion and their impacts are similar, paving the way for cooperation between enterprises, trade unions and the Governments.

In Argentina, the stock of NCMT increased from 350 to about 800 units between 1981 and 1988 (229%), while in Brazil, over the same period, the increase was from about a thousand units to circa five thousand. As for robots, at the end of 1988, there were 14 IRs in Argentina and 99 in Brazil. Moreover, all robots in Argentina seem to have been installed by 1986, while in Brazil the process of robotization has continued in the last two years, when 40 IRs (40% of the total number) were installed.

The number of users of NCMT in Brazil was estimated to be 150 in 1980 and in 1987 it had increased to about 420, about 30% of the number of potential users estimated in 1984.

In terms of sectors too, the use of NCMT seems to have spread over the recent years. In 1980, according to Tauile (1984), 66% of all NCMTs were concentrated in the industry producing machinery (especially machine tools) and 17% in the transport equipment industry (mainly automotive). In 1988, according to SOBRACON (1989), users of NCMTs included firms producing electrical and electronic durable consumer goods, steel, agricultural machinery and many other sectors. Nonetheless, machinery producers (especially machine tools and components), automotive producers (assemblers and parts manufacturers), air transport equipment and the defense industry still accounted for the bulk of installed NCMTs.

As mentioned above, NCMTs in Brazil tend to be very expensive on account both of the type of models produced and of the high cost of local production. Therefore, it is not surprising that diffusion of NCMTs started with large enterprises - in 1980 two-thirds of the users were firms with more than 500 employees (Tauile 1984). However, reflecting the changes in the supply of models and a relative decline of prices, the share of medium and small-sized users of NCMTs seems to be increasing. Thus, in 1984, in the State of Sbo Paulo, the share of users with more than 500 employees was 46% of the number of NCMTs (Leite et allii 1984).

In his seminal study of the introduction of NCMTs in Brazil, Tauile 1984 showed that 65% of all machines installed in 1980 were located in foreign-owned enterprises. Following the diffusion process outlined above, it is probable that such predominance has been greatly reduced.

In Argentina the present number of users of NCMTs is estimated to be around 150 enterprises (E. Cohen, personal information), 50% above the number estimated for 1981 (Chudnovsky 1985) - a rate of increase substantially lower than that observed above for Brazil.

As in Brazil, use of NCMTs in Argentina is concentrated on industries producing non-electrical machinery (especially machine tools, oil equipment and agricultural machinery) and transport equipment (automotive and shipbuilding). Differently from Brazil, however, the diffusion seems to have embraced medium- and small-sized enterprises from the outset, probably because the models of NCMT locally produced and imported were simpler and less expensive.

As regards IRs, in both countries the automobile industry, especially the assembly firms, is the main user of more complex, programmable IRs, especially for spot welding. Simpler models, mainly manipulators, are used mainly by producers of autoparts and capital goods. Nonetheless in Brazil their use is spreading beyond the boundaries of the metal-mechanic complex, including firms of the electronics complex (e.g. for the production of printed circuit boards) and of other industries, such as leather goods and plastics. In Argentina, as mentioned above, there is no indication of new users of IRs, which are concentrated in the transport industry (72% of the total number), capital goods industry (7%), steel (7%) and electronics (14%).

The full exploitation of the potential of electronics-based industrial equipments such as NCMTs and IRs, requires a "systemic" approach at the level of the firm. Not only the production process must be changed as regards material flows, labour skills and products characteristics, but also such transformatioans must be integrated with analogous changes at the level of design, sales, maintenance and management activities.

It is indicative of the incipient stage of diffusion of NCMTs in

Brazil that, in 1984, more than half of the users had only one machine installed. Moreover, 60% of the users continued to use conventional machine-tools side by side with the new NCMTs (Leite et al. 1984). A more recent study of modernization strategies in the metal-engineering industry (Fleury 1988) showed that, for 61 firms producing mainly machine tools, auto-parts and aeronautics equipment, "systemic" strategies were adopted only by 18 firms (30% of the total), with a relatively higher proportion within the auto-parts sample.

Similarly to Brazil, most NCMTs in Argentina are used as stand-alone pieces of equipment. It is estimated that less than ten per cent of the users had more than eight machines installed, with most users working with two or three machines (personal information by E. Cohen).

The degree of integration in the use of both NCMTs and IRs tends to increase with the size of the enterprise and its experience of use such equipment. In this respect, conglomerates which own producers of EAIE are in a favoured position to better use them, as is the case of the programmable IRs in Brazil and of programmable process controllers in Argentina, previously mentioned.

More generally, the mastery of the technology of use of IRs and CMTs is greatly facilitated by proximity between suppliers and users. As mentioned above, a considerable part of the activities of IR producers in Brazil at the present moment is alloted to developing the technology of use of their products, most of the time jointly with their customers, some of which are firms of the same group. This type of service, albeit in a minor scale, is also provided by NCMTs manufacturers.

In this respect, the situation in Brazil, where local production of NCMTs and IRs is much more developed than in Argentina and where local producers are obliged to develop technological capabilities internally, is much more favourable to diffusion than in the latter country.

Nonetheless, it is important to stress than several large companies with access to the technology of use of integrated automation, such as the subsidiaries of automobile and electronics companies, also show a pattern of use of EIAE,

especially IRs, more restricted than in the advanced industrialized countries.

Thus, at the level of the firm, and size there seem to be different patterns according to the ownership of the enterprise. Local firms seem to be going through a learning period, in which the smaller enterprises are at an initial stage, trying out the possibilities of the new technologies, using the equipment, mainly NCMTs, as stand-alone pieces, while the larger enterprises have advanced considerably along the learning curve, as is the case of leading producers of machine-tools and aeronautics equipment in Brazil and motorcycles and steel products in Argentina. Foreign subsidiaries, which also have followed a pattern of restricted diffusion, are not potentially constrained by the lack of access to user technology, but, since such technology has to become embedded in the technological and organizational "fabric" of the subsidiary, they also have to go through a period of learning how to use such equipment.

In order to better understand such processes of diffusion, it is convenient to examine in more detail the reasons given by the firms for the introduction of NCMTs and IRs, trying to sistematyze the evidence available from case-studies.(5)

In both countries, the literature shows that very few firms do a careful study of the economics of introducing the new equipment, although suppliers (especially the leading ones) tend to provide users with estimates (which probably are not totally unbiased).

Product characteristics, such as its complexity and strict margins of tolerance, seem to be the main reason for introducing NCMTs in both countries, especially among large users. Concern with costs, by reduction of idle time and of machining time, albeit important, tend to be secondary to product quality. Given the low level of wages prevailing in the two countries, it is not surprising that such costs tend to be marginal to the decision of introducing automated equipment. Labour unrest seems, however, to have been influential in some decisions in Brazil.(see below).

Product characteristics are closely related to their markets and in the two countries there is a clear relationship established between the use of NCMTs and IRs and exports - in order to supply international markets with products which conform to

international specifications, the firms consider that they have to use NCMTs and IRs.

Such double and "tied-in" international standardization, of products and capital goods, is especially visible in the introduction of IRs in the automobile industry, where the main determinant was the need to produce cars according to the specifications laid down by the parent companies world-wide.

Given the high cost of NCMTs and IRs, the importance of export markets for the introduction of NCMTs and IRs is heightened by the irregular and sluggish growth of the internal markets which would demand products subject to similar quality requirements, especially the State investments, which were sharply reduced in the two countries. Such constraints have been tightened by the lack of credit facilities for purchasers, although the latter have recently been eased, in Argentina by Italian and Spanish imports credit lines and, in Brazil, by new finance provided by the National Development Bank (BNDES).

Bearing in mind the severe foreign exchange constraint to which both countries are subject, due to their high indebtedness, the exchange earnings associated with the use of NCMTs and IRs are an important positive result of their diffusion.

The process of learning to use such equipments and the modernization of the overall structure of the enterprises which use them are benefits which befall on production directed to the internal market too, since exports absorb only part of the output of the users, especially in Brazil.

Notwithstanding the importance of such "spill-over" from exports, the diffusion of NCMTs and IRs, with its positive effects in terms of product quality, productivity increase and cost reductions, into a cumulative social process will depend on the recovery of a sustained high growth of domestic markets. The evidence available suggests that the Brazilian economy is better poised for such recovery than the Argentinian, compounding thus the differences already observed in both supply and demand for such equipment.

Turning to the negative effects of such diffusion, impacts on

employment - both on quantity and on skills - have drawn considerable attention in the two countries, as in more industrialized ones, where the diffusion process is more advanced.(6)

As regards job destruction, a rule of the thumb widely used in the two countries is that a NCMT replaces between three and five conventional machines and, from such rule, estimates are derived about the number of jobs lost because of the introduction of NCMTs.

Such estimates must be qualified. In the first place, as mentioned above, a considerable part of NCMTs so far introduced have not replaced conventional machines but are used side-by-side with them. Although this reflects the constrained patterns of diffusion previously discussed, which will in the future probably be superseded by a pattern where substitution is the rule, in the short run it mitigates the job destruction.

In the second place, we have the classical compensation effects of creation of jobs within the user firms, for programming, maintenance, etc. and the employment creation in the suppliers. Although there are no estimates available of such effects, they are probably greater in Brazil than in Argentina, because of the larger local content in the supply of technology and equipments.

Finally, there are the important findings of Fleury (1988), which show that firms which have followed strategies of modernization, especially, systemic strategies, have recovered faster from the crisis, both in terms of productivity and employment than the firms which did not modernize. It is not clear however, how much of such employment gains in the modernizing firms were offset by losses in the traditionally managed enterprises.

The impact of IRs on the number of jobs seems to be limited, not only because few IRs have been introduced but also because of the partial integration of the process of automation. Cohen (personal communication) estimates that around 40 jobs were lost in Argentina due to the 14 IRs installed, only partially compensated by some additional jobs for maintenance. For Brazil, studies reported in Tauile and Oliveira 1987, suggest that in the plants assembling automobiles the total number of jobs affected is small, but for specific tasks, such as welding and painting,

where most IRs are used, the impact may be significant, up to 30% of the total number of specialized welders in one firm. However, it is worth noticing that in the firm the latter result was observed, maintenance employment increased 60%.

There is a consensus in the literature of the two countries that the use of NCMTs and IRs has important effects on skill requirements of the work-force of the firms which employ such equipments.

The technological characteristics of the equipments, especially their information-processing capability, and their high cost tend to emphasize the need for higher levels of literacy, flexibility of response and trust. In both countries it is reported that operators of NCMTs often have tasks which go far beyond the cliche of simple "machine monitors" - e.g. they are frequently involved with the actual programming of the machine.

To cope with such problems, firms in the two countries have resorted to different methods. For instance, recruitment of NCMTs operators has followed two patterns: firms either tend to recruit young people just out of technical schools or they tend to use well-tried and trusted conventional machine operators from within the firm. The first strategy seems to stress flexibility, while the second emphasizes the elements of trust and knowledge of the firm's "culture".

In both countries operators and maintenance workers tend to get higher wages than in similar tasks unrerlated to microelectronics equipment. For example, Fleury 1988 found in his sample that NCMT operators tended to earn around 20% more than conventional machine tools operators and that such differential was even higher for maintenance personnel (28%).

Notwithstanding their original training, machine operators and maintenance personnel usually receive in-house training, which is extensive to other occupational categories involved with the new equipments (programmers, engineers, etc.).

Differently from the operation of conventional machine tools, which is a highly skiled activity, requiring many years of apprenticeship, the manual tasks which are replaced by IRs have a

relatively low skill content and often involve health risks. In fact, one of the reasons given by the firms for the introduction of IRs is the reduction of work hazards and conflicts.

Maintenance activities also have had their profile changed, with the addition of electronics and the upgrading of mechanics. To give an example, in the Brazilian automobile plant previously mentioned, the increase in employment of electronics maintenance was 237%.

At other levels of the firm, the evidence from the two countries confirm that changes are introduced in the occupational profile, increasing the importance of university-trained personnel, especially electronics engineers and of technical staff, such as programmers.

The early stage of learning of the technology of use of the new equipments and their high cost increase the need for cooperation between management, technical staff and workers, often leading the former to adopt procedures aiming at reducing labour conflicts.

At the same time, the adoption of the new equipment is often instrumental to reducing workers' bargaining power vis-a-vis management. At a time of severe strikes in the metal-working industry in Brazil, NCMTs were marketed as "labour-problems solvers".

Because of the crisis, which sharply reduced employment and real wages in the sectors which are the main users of NCMTs and IRs, trade union demands have concentrated on those two topics. Within this context, negotiations about the introduction of IRs and NCMTs have been actually limited, although labour leaders are aware of their potential importance.

7) REGIONAL AND BILATERAL COOPERATION BETWEEN ARGENTINA AND BRAZIL

The strategic role played by the electronics complex, combined

with the economies of scale, static and dynamic, prevailing in the complex and the relatively small size of national markets, provide ample scope for regional cooperation in this area.

Although such scope is widely recognized, actual regional cooperation at a multilateral level has, so far, been limited. Government authorities have established a forum (Conference of Latin American Authorities in Informatics - CALAI) with the aims of promoting the regional exchange of experience and information and the establishment of cooperative arrangements among Latin American and Caribean countries. The CALAI Permanent Secretariat has recently undertaken studies of software production and commercialization as well as on Latin America trade in informatics goods.

In the framework of the Economic System of Latin America (SELA) a Committee of Action for Cooperation in Informatics and Electronics was estabished in 1986 and ECLA and UNIDO have projects for cooperation in informatics and microelectronics.

Notwithstanding their usefullness as instruments of information, such initiatives seem to have had little economic impact.

As regards regional trade, Argentina, Brazil, Chile, Mexico and Uruguay subscribed an agreement to eliminate tariffs on informatics products within the framework of the Montevideo Treaty. However, the restrictions on trade put in force by Brazil, Mexico and Argentina as a consequence of their informatics industrial policies have rendered the agreement inoperative. The same applies to a regional preference for intraregional trade between Argentina, Brazil, Chile, Paraguay and Venezuela (Correa 1989b).

Bilateral cooperation between Argentina and Brazil has been much more successful, reflecting not only political decisions taken by the two Governments but also economic and geographic proximities between their two countries.

In 1986 the Governments of Argentina and Brazil signed a set of sectorial agreements within the framework of a Programme of Economic Cooperation and Integration between the two countries. Two years later the two Governments signed a Treaty of

Integration, Cooperation and Development which should lead to the creation of a free trade zone in ten years after the two Congresses have ratified the agreement, which did not happen yet.

The most successful of the sector agreements has been that designed for capital goods. As we saw above, exports of Argentinian NCMTs to Brazil have played a major role in sustaining the Argentinian industry, widening at the same time the market for Brazilian NC units. Therefore, we shall examine in some detail the rationale and instruments of the capital goods agreement (CGA) as well as some of its present limitations. Subsequently, we shall discuss the cooperation in electronics, which has been, so far, more limited.

The CGA establishes a partial free trade zone, circumscribed to capital goods. The universe of products embraces the majority of electrical and non-electrical machinery, their parts and components and non-automotive transort equipment. It excludes electronic products and automotive transport equipment, which is dealt with under another agreement (which has not progressed).

From such universe of products, the two countries are to agree on a "common list" for which mutual tariffs will be nil and all other import restrictions will be eliminated. Thus, the products included in the common list should be treated as "national products", with all the ensuing preferences vis-a- vis third parties.

As originally conceived the CGA should be a programme of industrial complementation between the two countries, based on intraindustry trade.

From the signature of the CGA to the present there were five rounds of negotiation of the common list. Within the list predominates non-electrical machinery produced in short batches (e.g. machine tools). Trade on parts and components is imited to a percentage of commerce of finished products. Cu tom-built equipments were excluded, pending upon specific negotiations, among others on purchase policies of State enterprises (which are the main market for such goods) and credit facilities.

As shown in Table 14 the CGA had remarkable results in terms of

volume of trade, which has increased four-fold over the period 1986/88. The Argentinian industry seems to have benefited most, increasing its exports to Brazil over sixteen times, turning a large trade deficit into a significant surplus in only three years. Machine tools are the main exports to Brazil, accounting for 47% of the total exports under the CGA. From a position of near equilibrium in 1986, the Argentinian trade surplus of machine tools has increased over 21 times. NCMTs account for almost half (48.3%) of total machine tools exports. As we saw above, electronic products were excluded from the CGA and Brazil retained her import restrictions on NC units in order to protect its infant industry. This has generated a flow of exports of NC units to Argentina which, in 1988, was equivalent to 22% of the Brazilian imports of Argentinian NCMTs.

In spite of such results there are considerable doubts about the capacity of the CGA, as it is now, to act as a force of transformation of the two industries.

As originally conceived, the CGA should provide the two industries with a widened market, warranting static economies of scale and economies of scope and specialization, leading to greater technological development and increased productivity on the two sides of the border. In order to fulfill such expectations, complementarities should be established between the two industries, both at a "horizontal" level, between finished goods, and at a "vertical" level, for the supply of parts and components, breaking away from the pattern of national substitution of imports which characterized the previous development of the two industries.(7)

However, in practice, the common list has, so far, been defined on the basis of offers of the producers of the two countries, which reflect their present comparative advantages. Since producers are the main negotiators and they must approve the inclusion of products in the common list, they are in a privileged position to avoid major competitive threats from the other country. As a consequence, the pressure emanating from the CGA to alter the lines of production is very limited.

Moreover, the two countries have postponed sine die the date on which their tariffs vis-a-vis third parties should be unified, partly because both were in a process of tariff reform, at the cost of leaving the relative margins of preference undefined.

Finally, several important Government measures which should complement the trade incentives and which are critical for the more ambitious restructuring objectives, such as the implementation of a fund for investments in the two industries and coordination of State purchasing policies, have not been yet fully designed. It is not clear yet if the new Governments, the two countries will have the political will to implement such measures.

Given such constraints, it is possible that as soon the obvious comparative advantages of the two sides have been included in the common list, the CGA may loose momentum, following a pattern already observed in other regional schemes of integration such as ALALC and ALADI. If this comes to happen a major opportunity for industrial and technological development shall have been lost by the two countries.

As mentioned above, some trade in electronic products was generated by the CGA, following the lines of intersection between the electronics and metal-mechanic complexes. However, the cooperation between Argentina and Brazil in electronics, formally, has centered around human resources and research and development.

In 1985 the Subsecretaria de Informtica y Desarrollo of Argentina and SEI of Brazil established a programme for education and research in informatics. After the programme was tested, in 1987 the Governments of the two countries signed a formal agreement of cooperation in this field, as a complement to their general agreement on scientific and technological cooperation. As Correa (1989, p. 113) comments, "it is one of the few cases in which concrete cooperation actions preceded the formal sanction of agreements".

Within this framework, the two Governments have sponsored yearly teaching meetings called the Argentinian-Brazilian School of Informatics, where are taught courses of different levels of complexity, for which specific text-books are prepared, and are held scientific and technological workshops. About 500 students of Brazil and Argentina and some 50 students of other Latin American countries go to each School, supported by the two Governments.

Partly as a result of the School, a common research programme was established between the two countries, focusing especially on software engineering, design and production of integrated circuits, non-conventional architectures and artificial intelligence. SEI and SID are also supporting the development of a heuristics workstation oriented to software engineering, which involves not only academic institutions but also industrial firms too.

More informally, the development of the Argentinian electronics policy, previously discussed, has benefited considerably from the Brazilian experience in this area. Such learning was facilitated by the commonality of objectives of the two policies and the interaction of Government officers and academics in structured (such as CALAI) and unstructured fora. It is probable that the controversy about the Brazilian policy for NC units influenced the Argentinian decision to not include such products in their top priority list for local production.

Economic and technological factors, such as scale economies and size of the markets, as well as common policy objectives present a strong case for furthering electronics cooperation into industrial activities.

However, there are considerable obstacles on this path. As in non-electronic capital goods, the local production of electronics goods has evolved following parallel lines, although covering a much narrower range in Argentina than in Brazil. Therefore, the same defensive attitude seen in capital goods is likely to arise among national producers of the two countries. It is also probable that greater integration between the two industries will require adjustments in the licensing and production strategies of multinational companies. Finally, a major obstacle is the criteria by which firms are considered "national" under the two policies, which are much stricter in Brazil than in Argentina. On one hand, the acceptance of Argentinian products as "nationally produced" by Brazil would mean the complete overhaul of the latters' electronics policy. On the other hand for Argentina to change its rule of "national" enterprise would mean a reversal of its present liberal policy towards foreign investment and a major political conflict with the forces which support the regime.

As shown above, the cooperation between Argentina and Brazil in capital goods and electronics had some favourable preconditions such as economic similarities, geographical proximity, Government will, etc. Some technological and economic factors reccommend such cooperation. Nonetheless, as we have seen, ceteris paribus, the prospect for increasing the integration already achieved is rather limited. Such constraints to further integration are not irrational and they often reflect legitimate economic, social and political interests. Among such interests it is probably useful to distinguish those which hold a purely "defensive" reaction against increased competition stemming from across the border, and who wish simply to lead a sheltered existence, from those which need protection for maturing purposes, conceding that, in practice, it is not always easy to separate one group from the other.

The ceteris paribus clause is, obviously, crucial, since, if some preconditions were favourable, the rest of the context, such as the macroeconomic turmoil, foreign indebtedness and the crisis of the State, was (and still is) extremely unfavourable to any long term structural policy such as that implied by a deeper industrial integration. Should that context change for the better, the prospect for greater integration would improve, probably more than proportionately. In the meantime, pursuing the possible integration, with expectations commensurate with such possibilities, seems to be sensible and necessary.

The analysis above, for reasons of time and space, as well as the scope of this study, concentrated on the Argentina-Brazil relationship. If, as the evidence available suggests, this is one of the most successful cases of integration within the region, deepening the analysis of this process in order to better identify the economic, political and technological elements which favour and constrain the integration would prove to be useful not only to the two countries concerned but also to the rest of the region, where integration seems to be, at the same time, more necessary and more difficult.

TABLE 1 - ARGENTINA AND BRAZIL - GROSS INTERNAL PRODUCT, (TOTAL AND INDUSTRIAL), AND INVESTMENT GROWTH RATES - 1961-1988 IN %

	YEARS				
VARIABLE	1961-70	71-80	81-83	84-87	88
GIP					
ARGENTINA	4.1	2.6	-2.9	0.6	-0.5
BRAZIL	6.1	8.7	-1.7	6.2	-0.3
INDUSTRIAL PRODUCT					
ARGENTINA	5.2	1.6	-3.9	-0.6	-5.5
BRAZIL	6.9	9.0	-5.7	6.8	-2.5
GROSS INVESTMENT					
ARGENTINA		3.7		-8.5	
BRAZIL		9.3		-2.7	
INVESTMENT RATE (I/GIP)					
ARGENTINA		21.7		15.2	
BRAZIL		23.9		16.6	

SOURCE - CHUDNOVSKY AND PORTA (1989)

TABLE 2 - ARGENTINA AND BRAZIL - EXPORTS STRUCTURE
- 1970 - 85 - IN %

	ARGENTINA			BRAZIL		
EXPORTS	1970	1980	1985	1970	1980	1985
1. PRIMARY PRODUCTS	59.5	49.0	49.3	64.2	30.3	27.6
2. AGRICULTURAL	59.1	48.5	48.2	57.1	21.3	21.0
3. MINERALS	0.3	0.4	0.2	6.9	8.9	6.6
4. MANUFACTURES	40.4	51.0	50.7	35.6	69.5	72.2
4.1 RESOURCE BASED	26.5	30.5	33.0	25.0	36.0	33.2
Agricultural	22.4	22.8	23.1	20.5	30.6	21.3
Minerals	1.3	4.2	4.4	1.0	2.3	5.4
Oil-derivated	2.8	3.5	5.6	3.4	3.0	6.5
4.2 NON-RESOURCE BASED	13.9	20.5	17.7	10.6	33.5	39.0

SOURCE - CHUDNOVSKY AND PORTA 1989

TABLE 3 - THE ELECTRONICS COMPLEX IN ADVANCED COUNTRIES-MAIN ELECTRONICS PRODUCTS MARKETS - IN % AND TOTAL VALUE 1988

PRODUCT	USA	JAPAN	EUROPE (1)	TOTAL
EDPE	41.4	17.5	39.8	39.8
CONSUMER	11.7	17.0	16.4	14.6
COMMUNICATIONS	12.8	8.9	19.1	13.0
AUTOMATION, INSTRUMENTS AND OTHER EQUIP.	14.0	7.4	9.0	10.6
COMPONENTS	20.1	29.2	17.7	21.1
TOTAL	100.0	100.0	100.0	100.0
VALUE (US$ Millions)	200.7	156.1	111.4	468.2

(1) FRG, UK, FRANCE, ITALY

SOURCE - Paiva (1988)

TABLE 4 - THE ELECTRONICS COMPLEX IN ARGENTINA AND BRAZIL - VALUE OF PRODUCTION AND STRUCTURE (IN US 1000 AND %)

COUNTRY	ARGENTINA		BRAZIL				
YEAR	1983		1986		1987	1988	(2/1)
	VALUE	%	VALUE	%	VALUE	% VALUE	%
SECTOR	(1)		(2)		(3)	(4)	
DATA PROCESSING	64.5	12.6	2126	33.4	2578	2465	33
TELECOMMS	124.4	22.4	636	10.0	617	1004	5
INDUSTRIAL AUTOMATION	36.6	7.2	199	3.1	294	309	7
INSTRUMENTS			55	0.9	77	74	
(CAPITAL GOODS S. TOTAL)	(225.5)	(44.2)	(3016)	(47.4)	(3566)	(3852)	13.4
CONSUMER GOODS	238.0	46.6	3137	49.3	n.a.	n.a.	13
COMPONENTS	46.8	9.2	209	3.3	242	348	4.5
TOTAL E C	510.3	100.0	6362	1000	n.a.	n.a.	2.5

SOURCES
Argentina - Azpiazu, Basualdo and Nochteff (1988)
Brazil - SEI (1989), except consumer goods from Tigre (1988)

TABLE 5 - ARGENTINA - SHARE OF PRODUCTION OF ELECTRONICS HELD BY MNCs. - 1978 and 1983 -(IN %)

PRODUCTS	YEAR 1978	1983
CONSUMER GOODS	21.9	28.0
TELECCOMMS	65.1	87.6
EDPE	77.0	93.0
INDUSTRIAL AUTOMATION AND INSTRUMENTS	10.0	60.8
COMPONENTS	58.4	56.0
TOTAL	40.8	56.0

SOURCE - AZPIAZU, BASUALDO AND NOCHTEFF (1988)

TABLE 6 - BRAZIL - SHARE OF ELECTRONICS PRODUCTION HELD BY MNCs - 1980, 1985, 1988 - IN %

PRODUCTS	YEARS 1980	1985	1988
EDPE	67	49	39
TELEINFORMATICS	n.a.	56	29
INDUSTRIAL AUTOMATION	100	n.a. (2)	03
MICROELECTRONIC COMPONENTS	n.a.	48	40
TOTAL	67 (1)	48	33

NOTES
(1) Using EDPE data only
(2) Data for 1986
SOURCE - SEI (1989)

TABLE 7 - BRAZIL - MAIN ELECTRONICS INDUSTRIAL AUTOMATION EQUIPMENT - NET (1) SALES IN 1988 - IN US$ 1000

PRODUCT	VALUE
PROCESS CONTROL	123.9
PROGRAMABLE CONTROLLERS	38.6
DIGITAL SYSTEMS OF DISTRIBUTED CONTROL	35.2
SYSTEMS OF SUPERVISION AND CONTROL	18.2
REMOTE TERMINAL UNITS	15.3
DIGITAL PROCESS CONTROLLERS	10.9
INDUSTRIAL COMPUTERS	3.5
SEMIGRAPHIC TERMINAL	1.8
TRAFFIC CONTROLLER	0.4
MANUFACTURE AUTOMATION	39.6
CNC	18.1
WORK STATION	10.9
ROBOT SYSTEMS	1.6
PLOTTERS & OTHER GRAPHIC INST.	9.0
AUTOMOTIVE ELECTRONICS	2.3
TOTAL	165.8

(1) Sales net of taxes
SOURCE - SEI (1989)

TABLE 8 - BRAZIL - NUMERICAL CONTROL UNITS PRODUCTION - NUMBER OF UNITS AND VALUE (US$ MILLIONS)

YEAR	NUMBER OF UNITS		VALUE	
	SOBRACON	SEI	SOBRACON	SEI
1984	253	174	n.a.	n.a.
1985	413	364	n.a.	n.a.
1986	757	608	22.2	22.0
1987	1138	956	20.0	35.0
1988	816	1041	13.9	18.1

(1) Data from SEI refer only to CNC. Sales value is net of taxes

SOURCES - SEI (1989), SOBRACON (1989)

TABLE 9 - CNC PRODUCTION IN BRAZIL ACCORDING TO MARKETING AND SOURCE OF TECHNOLOGY STRATEGIES - NUMBER OF FIRMS, UNITS PRODUCED AND VALUE OF PRODUCTION

1988

A - NUMBER OF FIRMS

MARKETING	TECHNOLOGY LOCAL	TECHNOLOGY IMPORTED	TOTAL
MERCHANT	3	1	4
CAPTIVE	1	2	3
TOTAL	4	3	7

B - UNITS

MARKETING	LOCAL N	LOCAL %	IMPORTED N	IMPORTED %	TOTAL N	TOTAL %
MERCHANT	490	92	350	68	840	81
(%)	(58)		(42)		(100)	
CAPTIVE	40	8	161	32	201	19
(%)	(20)		(80)		(100)	
TOTAL	530	100	511	100	1041	100
(%)	(51)		(49)		(100)	

C - VALUE - IN US$ 1000

MARKETING	LOCAL US$	LOCAL %	IMPORTED US$	IMPORTED %	TOTAL US$	TOTAL %
MERCHANT	3692	100	8135	56	11827	65
(%)	(31)		(69)		(100)	
CAPTIVE	n.a.(1)	-	6316	44	6316	35
(%)	(-)		(100)		(100)	
TOTAL	3692	100	14451	100	18143	100
(%)	(20)		(80)		(100)	

NOTE (1) - Unknown but small
SOURCE: Our estimates based on data from SEI 1989

TABLE 10 - ARGENTINA AND BRAZIL - NUMBER OF MACHINE TOOLS PRODUCED (IN 1000 UNITS) - 1970-1988 - SELECTED YEARS

YEAR	MACHINE TOOL PRODUCTION (IN 1000 UNITS) ARGENTINA	BRAZIL
1970	14.2	n.a.
1973	22.5	n.a.
1978	12.6	36
1979	10.6	73
1981	4.4	28
1985	2.5	22
1986	3.9	29
1987	4.2	30
1988	2.7	n.a.

SOURCES:

ARGENTINA - 1979/81 - CHUDNOVSKY (1985)

1985/87 - AAFMHA

BRAZIL - ABIMAQ

TABLE 11 - ARGENTINA - MACHINE TOOL PRODUCTION, IMPORTS AND EXPORTS IN NUMBER OF MACHINES AND VALUE (US$ MILLIONS) 1985/88

	1985	1986	1987	1988
1) PRODUCTION				
NUMBER	2467	3958	4446	2763
VALUE	25.40	27	31.30	42
2) EXPORTS				
NUMBER	406	382	1257	942
VALUE	2.0	2.50	15.90	32.40
3) IMPORTS				
NUMBER	3413	1287	n.a.	n.a.
VALUE	31.40	16.40	38.30	44.60
4) APPARENT				
CONSUMPTION = (1) + (3) - (2)				
NUMBER	5474	4863	n.a.	n.a.
VALUE	54.80	40.90	53.70	54.20
5) IMPORT COEFFICIENT (%) = (3)/(4)				
NUMBER	62.30	26.50	n.a.	n.a.
VALUE	57.30	40.10	71.30	82.30
6) EXPORT COEFFICIENT (%) = (2)/(1)				
NUMBER	16.40	9.60	28.30	34.10
VALUE	7.90	9.30	50.80	77.10

SOURCE: A.A.F.M.H.A.

TABLE 12 - BRAZIL - MACHINE TOOLS PRODUCTION, IMPORTS AND EXPORTS IN NUMBER AND VALUE (US$ MILLIONS) - 1985/87

	1985	1986	1987
1) PRODUCTION			
NUMBER	21963	28701	29871
VALUE	352	551	523
2) EXPORTS			
NUMBER	5113	8772	6704
VALUE	28	26	24
3) IMPORTS			
NUMBER	17781	10883	2648
VALUE	40	65	113
4) APPARENT CONSUMPTION = (1) + (3) - (2)			
NUMBER	34631	31512	25815
VALUE	364	590	612
5) IMPORT COEFFICIENT (%) = (3)/(4)			
NUMBER	51.30	34.50	10.30
VALUE	10.90	11	18.50
6) EXPORT COEFFICIENT (%) = (2)/(1)			
NUMBER	23.30	28.10	22.40
VALUE	8	4.70	4.60

SOURCE: ABIMAQ

TABLE 13 - BRAZIL - NCMT - PRODUCTION AND IMPORTS

A - UNITS

YEAR	LOCAL PRODUCTION (1)	IMPORTS (2)	TOTAL (3)	STOCK (4)	IMPORT COEFFICIENT (%) (5)=(2)/(3).100
UNTIL 1979	110	274	384	384	71.4
1980	172	306	478	862	64.0
1981	69	55	624	986	8.8
1982	120	30	150	1136	20.0
1983	150	30	180	1316	16.7
1984	153	53	206	1522	25.7
1985	413	60	473	1995	12.7
1986	833	180	1013	3008	17.8
1987	1018	150	1168	4176	12.8
1988	742	n.a.	n.a.	4918	n.a.

B - VALUE - IN US$ MILLIONS

YEAR	LOCAL PRODUCTION
1986	187.0
1987	197.7
1988	223.6
1989 (1)	226.20

(1) ESTIMATE

SOURCE: SOBRACON

TABLE 14 - CAPITAL GOODS TRADE BETWEEN ARGENTINA AND BRAZIL UNDER THE CAPITAL GOODS AGREEMENT IN US$ 1000 - 1986/88

	YEARS					
	1986		1987		1988	
	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX
(1) EXPORTS FROM ARGENTINA						
TOTAL CAPITAL GOODS	2131	100	17888	839	35575	1669
MACHINE TOOLS	631	100	7961	1261	17577	2785
NCMT	n.a.		3436	100	8911	259
(2) EXPORTS FROM BRAZIL						
TOTAL CAPITAL GOODS	14591	100	25267	173	33122	227
MACHINE TOOLS	553	100	952	172	693	125
NCMT	n.a.	n.a.	n.a.	n.a.	n.a.	
BALANCE: (1) - (2)						
TOTAL CAPITAL GOODS	-12460		-7379	2453		
MACHINE TOOLS	78	100	7009	16884	21646	
NCMT	n.a.	n.a.	n.a.	n.a.		
TOTAL TRADE: (1) + (2)						
TOTAL CAPITAL GOODS	16722	100	43155	258	68697	410
MACHINE TOOLS	1184	100	8913	752	18270	1543
NCMT	n.a.	n.a.	n.a.	n.a.		

SOURCE: Secretaria de Industria y Comercio Exterior

NOTES

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(1) For a more detailed analysis of Brazilian industrial comparative advantages see Erber, Araujo Jr. and Tauile (1985).

(2) For different views of the prospects the newly industrializing countries and their even less developed brethren face in the context of the new "industrial revolution" heralded by electronics, compare Erber (1984) and Perez (1986).

(3) Recent national studies include Azpiazu, Basualdo and Nochteff (1988 and 1989) for Argentina and the several monographs in Piragibe (1988) for Brazil. For recent comparisons between the two countries see Correa 91989 and 1989a) and BID (1988).

(4) The main source of information on IRs in Brazil is Laplane (1988).

(5) See Azpiazu, Basualdo and Nochteff (1988b) and Casalet (1988), Chudnovsky (1985, 1988) for Argentina. I also benefited from the case studies of E. Cohen, personally conveyed. For Brazil, see Fleury (1988), Laplane (1988), Leite et al. (1984), Tauile (1984, 1987) and Tauile and Oliveira (1987) and references therein.

(6) See references in the proceding footnote.

(7) See Chudnovsky and Porta (1989) and Porta (1989) for detailed analyses of the CGA.

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