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MACHINE TOOLS IN LATIN AMERICA*

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* The views expressed in this paper are those of the authors 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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INTRODUCTION

This regional study on machine tools analyses the conditions of their production, use and trade in Latin America, with special emphasis on flexible automation equipment.

The study is divided in four sections. The first one gives an overview of machine tool production and the organization of the industry in selected countries of Latin America. The second section presents the main patterns of industrial policy adopted for the industry in the Region. The third section deals with technological evolution of the industry, focusing first, on the diffusion of flexible automation in manufacturing industry; second, on the production of flexible automation equipment in Latin America; and third, on the effects derived from the use of flexible automation and related new forms of organization, in machine tool production itself. The last section discusses the main international trade issues of the industry.

This report is based on recent country and regional case studies, some of which were specially prepared for UNIDO.

The authors acknowledge the collaboration of Edson Peterli Guimarães in the fourth section of the report. The responsibility for errors and omissions is, however, solely theirs.

I - MACHINE TOOL PRODUCTION: AN OVERVIEW

I.1 - The Production of Machine Tools

Latin America makes a marginal contribution to the worldwide production of machine tools - less than 2% of the industry's production value at world levels in 1988. This contribution is significantly lower than the one made by the Latin American manufacturing industry to world industry.

Within the Region, machine tool manufacture is concentrated in Brazil, which, in 1988 has produced, in terms of production value, ten times more than Argentina, the second major manufacturer. According to the Brazilian Machine Tool Manufacturers Association (ABIMAQ) estimates, approximately 34,000 units were manufactured in 1988 at a value of US$ 536 million dollars. The data for Brazil, supplied by the American Machinist, as reported by Chudnovsky (1990), is slightly inferior to ABIMAQ's - roughly 10% - , but that difference is not significant in view of exchange rate fluctuations and other variations in criteria for measurement.

Concerning Argentina, Chudnovski (1990) has estimated the country's total production in 1988 at 5,600 units at a global value of 48 million dollars. The Argentinian Machine Tool Manufacturers Association (AAFMHA), however, has estimated 2,700 units at 42 million dollars, while the American Machinist calculated production value at 38 million dollars. With regard to Mexico, the third largest manufacturer in the Region, Humbert's (1989) data points to an output of about 1,000 units per year and a value estimated by the American Machinist at approximately 18 million dollars (see Table 1).

TABLE 1
MACHINE TOOL PRODUCTION, EXPORTS AND IMPORTS
IN SELECTED LATIN AMERICAN COUNTRIES - 1988
in US$ million and thousand units

	PRODUCTION		EXPORTS	IMPORTS	IMP/CONS	EXP/PROD
COUNTRY	VALUE	UNITS	VALUE	VALUE	%	%
BRAZIL	536	34.5	40.0	163,8	24.8	7.5
ARGENTINA	49	5.6	32.6	44.6	73.1	67.0
MEXICO	18	1	2.5	240.0	93.9	13.9
PERU	0.8	0.17	0.03	11.2	93.3	3.3

Sources:
BRAZIL - ABIMAQ (1989)
ARGENTINA - Chudnovsky (1990)
MEXICO - Values - American Machinist, in Chudnovsky (1990):
Units produced - Humbert 1989
PERU - Gonzalez Roda (1990).

Similar differences can be found concerning the number of employees. In 1987, the Brazilian machine tool industry counted on approximately 20.000 employees, whereas the Argentinian industry employed less than 2000 and the Mexican one about 300 people (data from ABIMAQ 1989, Chudnovski 1990, and Humbert 1989, respectively).

In the remaining Latin American countries, machine tool production is even more limited. For instance, in the period 1985-1988, a mere 418 units were produced in Peru. In the latter year, the value of production was about US$ 830.000. That output consisted chiefly in the assembly of imported equipment, rather than manufacture proper, and employment reached roughly 300 workers (Gonzalez Roda, 1990). In Colombia, by 1982, there were approximately fifteen machine tool producers, half of which manufactured machine tools along with other capital goods, with a total employment number of about 500 (Chudnovsky, 1990). In Bolivia, production of non-electrical machinery hardly reached 6 million dollars in 1986, there being no machine tool production as a specific entrepreneurial activity (Gonzalez Roda, 1990).

The difference between the Brazilian machine tool industry and its counterparts in other Latin American countries far exceeds the differences observed between their respective industrial products, reflecting the Brazilian industrialization strategy of giving relatively higher priority to the local manufacture of capital goods.

The machine tool industry in the Region has suffered important reductions along the last decade. In terms of units manufactured in Brazil, over 70.000 machines were produced in 1979, i.e., more than twice the figure for current production. In Argentina, where the reduction in the number of manufactured units dates back to the mid-seventies, four times more machines were produced in 1973 than in 1988. No estimates are available concerning the number of units manufactured in Mexico, but the value figures for the small 1981 output are one third higher than those relating to 1988 (Humbert, 1989).

As for the type of equipment produced, table 2 below shows that in Brazil the share of metal cutting machines is the same as the world average (77% of the value of production). Mexican production puts a greater emphasis on this type of equipment, which accounts for 83% of machines produced locally (Humbert, 1989). In Argentina, on the other hand, the proportion of cutting machines does not reach world average levels, corresponding to only 71% in 1988.

TABLE 2

MACHINE TOOL PRODUCTION IN LATIN AMERICA
by type of machines (metal cutting/metal forming)
in units, value and % of total production

Country	Year	Metal cutting				Metal forming			
		N	%	V	%	N	%	V	%
Brazil	1988	30717	89	414	77	3737	11	122	23
Argentina	1987	n.a.	n.a.	27	71	n.a.	n.a.	11	29
Mexico	1986	n.a.	n.a.	15	83	n.a.	n.a.	3	17
Peru	1988	212	51	389	47	206	49	430	52
World	1987	n.a.	n.a.	29009	77	n.a.	n.a.	9038	23

Sources:
Brazil- ABIMAQ (1989)
Mexico- Humbert (1989)
Argentina- Chudnovsky (1990)
Peru- Gonzalez Roda (1990)
World- American Machinist in Chudnovsky (1990)

The introduction of microelectronics into the machine tool industry, has led to a true technological revolution. Significant diffusion of numerical control began to take place during the seventies, and in Japan, by 1988, NCMTs accounted for over 70% of the entire machine tool industry's production value. In other advanced countries, whereas NCMTs'share was somewhat smaller, it surpassed 50% of the output value (Chaponniere, 1990).

In Latin America, production of NCMTs is concentrated in Brazil, with an output of roughly 1,000 units per year - approximately 10 times more than Argentina, the other significant manufacturer in the region. In Mexico, only five NCMTs were manufactured in a period of two years, while the remaining countries seem to have no production whatsoever of such equipment. NCMT production in the region is chiefly composed of cutting machines, particularly lathes, and, to a lesser extent, machining centers and milling machines.

In Brazil, the share of NCMTs in the industry's production value, amounting to 38% in the period 1986/88 and 42% in the last year, is getting close to the values found in the advanced countries. However such results may be strongly influenced both by the average low level of complexity of machine tool production and by the high price of the Brazilian NCMTs. In fact, in terms of number of units produced, NCMTs accounted for about 3% of the total production of machine tools in the period 1986/88, as can be seen in table 3.

Table 3

TOTAL MACHINE TOOL PRODUCTION AND NCMT PRODUCTION
IN BRAZIL AND ARGENTINA - 1986/1988
in units and value (US$ million)

Year	Number of units			Value		
	Total MT	NCMT	%	Total MT	NCMT	%
			Brazil			
1986	28701	833	2.9	552	187	33.9
1987	29871	1018	3.4	523	197	37.7
1988	34454	742	2.1	536	223	41.6
1986/88	87527	2593	2.9	1611	607	37.7
			Argentina			
1986	4410	34	0.8	33.0	3.3	10.0
1987	5360	100	1.9	39.9	10.2	27.3
1988	5639	96	1.7	48.6	11.9	24.5
1986/88	15409	230	1.5	121.5	25.4	20.9

Sources : Brazil- total machine tool: ABIMAQ
NCMT: SOBRACON
Argentina- Chudnovsky 1990

In Argentina, NCMTs accounted for a fourth of the value of total machine tool production over the period 1986/1988 and for 1.5% of the number of units produced (see table 3). Nonetheless the increase since 1986 is noteworthy.

The CNC units used in Brazil are locally produced, while in Argentina they are imported. In order to enter the Brazilian market under the terms of the Integration Agreement between the two countries, Argentinian firms have often Brazilian CNC units, despite their high cost (see below).

The large difference in machine tool production levels between Brazil and the other countries in the Region reflects the Brazilian strategy of fostering import substitution. This process was so intensive that by the mid-eighties only approximately 10% of the apparent consumption of machine tools in Brazil depended upon imports. Although machine tool imports have had a fourfold increase in terms of value between 1985 and 1988, their participation in apparent consumption in the latter year reached approximately 25%, a substantially lower level than the world average, which amounts to 41% (see table 1).

The estimates above, for import participation in apparent consumption in Brazil are based on data obtained from ABIMAQ and CACEX (ABIMAQ 1989). Chudnovsky (1990), using information from the American

Machinist, estimates import participation in apparent consumption at only 8.8%. This is due to the fact that this publication has estimated machine tool imports at only US$ 40 million , or less than one-fourth of the value US$ 163 million indicated by CACEX. The "world" figures refer to the 36 main producers listed by The American Machinist.

Contrasting with the high degree of self-supply of machine tools found in the Brazilian economy, the apparent consumption of machine tools in Argentina and Mexico is strongly dependent upon imports, which reach levels of 74% and 94%, respectively. In Peru, that figure also reaches 94% (Gonzalez Roda, 1990) (see table 1).

In most Latin American countries machine tool production is basically geared to the domestic market. In Brazil, although exports climbed from 28 to 40 million dollars between 1985 and 1988, they still represented only 7.5% of the total production. As for Mexico, that figure reached 14% in 1988, while in Peru it was equivalent to only 3.3%. The big exception is Argentina, whose exports in 1988 corresponded to roughly 67% of their production, a far higher percentage than the international average of 45% (Chudnovski, 1990; see table 1). As discussed in more detail in Section IV, below, such exports consist mainly of intra-regional trade.

The forgoing data witnesses the insufficiency of machine tool industry development in Latin America, except for Brazil. That insufficiency, which has been pointed out by many authors (for instance, Fajnzylber, 1983) as one of the specificities of the Region's industrialization pattern, has been severely aggravated in the last decade by a twofold order of factors.

First, at the domestic level, the aggravation was due to the economic crisis, which led to a marked drop in the rate of investment and to foreign adjustment policies that were characterized by import liberalization, in a process of cumulative causation. Therefore, there has been not only a drop in the demand for machine tools, but where that demand did exist it was possible to cater to it through imports. A case in point regarding this process has been Argentina.

Having occurred simultaneously in the entire Region, the economic crisis affected Latin American machine tool manufacturers not only in their domestic markets but also in terms of their major export markets, thus generating negative synergic effects.

Second, the machine tool industry at the international level has been going through a veritable technological revolution grounded on the application of microeletronics. In Latin America, technological change is being postponed both by a general retraction of the regional market, which discourages investments on new technologies, and by the Region's lack of an electronics complex and a scientific and technological system close enough to machine tool manufacturers to be able to provide them with the means required to change their technical basis. Consequently, to the insufficiency in production capacity was added a widening of the technological gap which separates the Latin American machine tool industry from the international frontier.

The Brazilian situation stands as a partial exception to the forgoing picture. In this country, which, as we have seen, probably accounts for over 80% of the Latin American machine tool industry, the import substitution process in the second half of the seventies encompassed this and other branches of the capital goods industry, with a view to overcoming the limitations inherent in this type of industrialization.

The import substitution process has been extended to the supply of parts and components, normally under the form of a backward verticalization of machine tool manufacturers. As a consequence the Brazilian machine tool industry has suffered from a poor development of the network of independent specialized suppliers that is characteristic of advanced countries, and from the lack of subcontracting practices among manufacturers (Chaponniere, 1990).

The level of integration attained by the Brazilian machine tool industry has the obvious advantage of creating a local production capacity protected against hard currency restrictions, in compliance with one of the objectives of the import substitution policy. The form taken by its implementation, however, has the disadvantage of reducing static and dynamic economies of scale and of curbing the synergy and learning effects that are characteristic of industrial systems endowed with better labor division and specialization.

During the eighties, the macroeconomic adjustment and the fall in the rate of investments in Brazil, despite their recessive character, were less severe than in the rest of the Region. Therefore, though affected by the crisis, the Brazilian machine tool industry managed to maintain the level of activity required for its survival.

At the same time, the Brazilian government sought to face the challenge posed by the technological revolution in the machine tool industry by setting up, through market reserve, the conditions for microelectronic control devices to be designed and manufactured in the country. That policy has had controversial results: on the one hand, it favored the establishment of an important segment of the electronics complex with close connections to the machine tool industry, yet on the other hand it caused the products of the latter industry to be substantially more expensive, thereby limiting their diffusion in the domestic market and their competitiveness in the international market.

In other words, while in most Latin American countries the machine tool industry is virtually at a stage of creation, or rebuilding (as in Argentina), in Brazil it is currently going through a maturing period while involves a crisis of adjustment to a new technical basis.

I.2 · The Machine Tool Industry Organization

In Brazil three major groups of machine tool producers can be distinguished according to the type of equipment manufactured and to the origin of the companies' ownership. The first group is made up of roughly one dozen medium or large-size foreign company subsidiaries, mostly of German origin, which were attracted to Brazil by its domestic

market, especially in the automobile industry. Although their settling in the country meant being present in the Latin American market at large, their exports to the latter have been relatively few. They manufacture transfer lines, special production machines, numerically controlled lathes and broaches, machining centers, and high performance presses.

Those companies operate with design and manufacture technology provided by their parent head offices, but were recently forced to increase their local technical capacity in order to adjust their products to the domestic supply of electronic components, particularly computerized numerical control units. One of these companies holds an exclusive OEM contract with one of the local manufacturers of numerical control (NC) units. Their chief markets are the automobile industry (both assemblers and auto parts producers), aviation and the remainder of the machine tool industry.

The second group is composed of the leading Brazilian-owned companies and also counts on roughly ten large and medium size concerns. In point of fact, this is the group where we find the leading Brazilian company in the sector - a major producer by international standards, with an output of over 3,000 units per year, sales above 40 million dollars, and more than 2,000 employees. Unlike the first group, however, most major national companies have concentrated their production on conventional machine tools and have only recently begun to manufacture NC machines. It is worth noting that the leading company produces NC units for its own use.

The companies integrating this group follow technological strategies that combine the utilization of their internal design and production capacity with the employment of foreign technology imported under license agreements, particularly in connection with the design engineering of more complex machines. While their internal technological capacity was originally developed on the basis of copying and adaptation activities, they now show a tendency toward a systematization of their research and development activities through specialized departments. Outstanding among them is the sector's forementioned leading firm, which counts on a specialized R&D and training center and invests about 5% of its revenues on those activities, a high allocation even by international standards.

Finally, a third group is formed by about eighty small and medium size nationally-owned companies employing less than 500 workers each and manufacturing conventional universal machines. In all likelihood, they have been the ones which were most deeply affected by the recent crisis as regards sales and technological capacity, and they have been having a hard time bringing themselves up to date, even in terms of introducing NCMTs in their production process.

The first two groups of companies answered for about 44% of the industry's total production value in 1985. That concentration becomes proportionally higher if we consider only the five major manufacturers (three of which are German companies' subsidiaries), given that they account for one third of the industrial production value (Erber, 1989).

In Argentina, Chudnovski and Groisman (1987) have identified four major groups of companies in terms of sales and technological level. The first group includes three concerns that have been routinely producing numerical control machine tools (NCMTs), namely lathes, milling machines, and machining centers. They operate with licensed imported technology and with imported electronic components, but they also have a strong internal design capacity based on experience. One of such firms has a subsidiary in Brazil, which manufactures special machines, and acts as a sale office for its NCMTs.

A second group is formed by three companies that manufacture forming machines, particularly presses, and two producers of lathes, one of which manufactures special machines. The two latter firms have been producing NC lathes on an irregular basis. The third group is composed of about 30 companies, especially small size ones, all of which have been largely affected by the crisis as regards production and technological capacity. Last of all, there is a group made up of several small size companies that operate chiefly as either subcontractors for relatively simple operations or repair shops, that are equipped with very limited machinery and technological capacity.

The same authors report that, according with the census data for 1984, the four major concerns accounted for one third of the industry's production value. That concentration is far larger, however, at the level of specific products, particularly the more complex ones. Thus, in 1986, two out of twelve companies answered for 57% of the total production of lathes and 90% of the production of NC lathes. The most extreme case is that of machining centers, which were manufactured by only one firm.

Despite its high concentration levels, the Argentinian industry is made up of small and medium size companies, leading enterprises themselves counting on no more than 200 employees each (Chudnovski, 1990).

In Mexico, Humbert (1989) has reported the existence of 13 manufacturers in 1985, out of which seven produced metal cutting machines. The number of manufacturers has since been reduced. As regards lathes and milling machines there are only four producers left, of which only one manufactures CNC-equipped machines, with a total production of five units in the years 1988-1989. The Mexican firms are small concerns whose size can be assessed, for instance, by the direct employment they generate: one has 12 employees, two others have 85 each, and the largest one has 112 workers (ibid.). It should be noted, however, that the first of the forgoing companies, despite its small size, is the only manufacturer of numerical control machine tools.

The largest of those four manufacturers and one of the medium-size companies are nationally-owned. The other medium-size company is a foreign subsidiary and the smallest concern is a joint venture with 51% ownership by Mexican capital. The largest firm is the only one to operate with national technology, whereas the remaining companies import technology from abroad. It must nevertheless be noted that the

foreign technology suppliers do not seem to be companies operating at the industry's frontier.

In Peru, out of the 20 companies operating as manufacturers and/or imported product assemblers, a total of only 8 are permanent producers. Among these, one is a small company which manufactures jewelry lathes with national technology and the remaining are medium size manufacturers of presses (6 companies), milling machines (2 companies), and turret and parallel lathes (1 company). Local technological capacity seems to be more developed as regards presses, so that three of the Peruvian manufacturers use local technology while two import it from abroad (one manufacturer did not supply any information). Lathes and milling machines are produced with imported technology and it is worth mentioning the role of Brazilian companies as technology suppliers for lathes and presses, and Argentinian firms for milling machines (Gonzalez Roda, 1990).

Out of the fifteen firms that manufactured machine tools in Colombia in 1982, three operated with imported technology secured under license agreements and the remaining ten had developed their products locally by means of copying and adjusting practices (Chudnovsky, 1990).

An extreme case of insufficiency in machine tool industry development in Latin America seems to be Bolivia. To judge from the information presented by Gonzalez Roda (1990), such industry does not exist in that country as a distinct entrepreneurial activity, except perhaps in terms of some repair work. The machine tools installed in the country are concentrated in either large State-owned companies (railways and mining) or large private industrial and mining concerns.

Most of the remaining countries in the Region are likely to hold positions varying between the above described Peruvian and Bolivian conditions, according to their development level.

II. INDUSTRIAL POLICY.

The heterogenity in machine tool industry development observed in Latin America is closely associated to the type of governmental policies adopted in its various countries. Three policy patterns may be distinguished in the Region.

The first one, which applies to Brazil, reflects the government's aim to set up a complete machine tool industry in the country. The second type corresponds to the Mexican and Argentinian cases, where after the adoption of an import substitution policy based on protecting the domestic market, that policy was relinquished in favor of a liberation of imports. Finally, a third pattern, which would seem to apply to the remaining countries in the Region, gives low protection to the local production and encourages imports either of finished machines or of parts and components for final assembly.

The three policy patterns have brought about distinct advantages and disadvantages. In the Brazilian case, a whole range of policy instruments were used along two complementary lines. On the one hand, protection against imports was granted to the local production through tariff and, particularly, through non-tariff barriers , outstanding among which were the law of similarity and a hard-currency budgeting per company. On the other hand, certain measures were established to foster the creation and expansion of machine tool manufacturers in the country, especially by official credit agencies. Credit lines, often granted at subsidized real interest rates, covered the investment of machine tool companies through the National Development Bank (BNDES) and the sale of their products through a subsidiary of BNDES (FINAME). More recently and in a smaller scale, credits have also been granted through a Science and Technology Development Bank (FINEP) to foster the companies' technological capability.

As already mentioned, those policies have been enforced all along the productive chain of the machine tool industry. Consequently, machine tool production in Brazil is now burdened with the high costs of its inputs and components.

The domestic cost of most inputs, except for steel materials and plates, non-ferrous materials and electric engines, is higher than the cost of eventual imports, as can be seen in Table 4. Particularly outstanding is the high cost of mechanical components, bearings and electronic components, which is nearly thrice superior to import costs. As a result thereof, Brazilian machines have a substantially higher variable cost than the one prevailing in more developed countries, such as Great Britain, Italy, Japan, the Federal Republic of Germany, and Spain. That difference is higher in regard to technologically more complex machines, such as three- and four-axle CNC lathes and machining centers (precisely because a larger amount of the more expensive inputs goes into them) than in regard to conventional machines.

Table 4

Inputs for the machine tool sector in Brazil.
Ratio between domestic and international prices

Inputs	Domestic price*/ Import price*
Steel and plates	0.938
Ferrous castings	1.320
Non-ferrous materials	0.300
Electrical engines (A.C.)	0.517
Electrical components	1.710
Electronic components	2.773
Hydraulic components	1.814
Ball bearings	2.947
Forged parts	1.220
Other mechanical components	3.097
Other raw materials	2.097

* - prices net of taxes

Source: ABIMAQ-SINDIMAC, Research on Industrial Policy

The low labor costs in Brazil do not seem (as reported by producers) enough to compensate for those differences, given that the labor employed in machine tool manufacture is more highly skilled than the average workers available in Brazil, thus forcing the companies, especially the leading ones in the sector, to carry out their own training programs.

Notwithstanding that, a substantial if not quantifiable portion of the high cost of machine tools in Brazil can be attributed to the high mark-up practiced by Brazilian companies, which is favored both by the market's segmentation and the protection against imports.

In short, if the policy pattern observed in Brazil has led to the establishment of an internationally significant industry, on the other hand it has burdened the industry's consumers with relatively expensive products. Consequently, along with the forementioned technological updating, the major challenge currently posed to governmental authorities and machine tool manufacturers in Brazil lies in reducing the cost of such equipment to its users, in order to enable its further diffusion. There are some preliminary indications from the present government to the effect that the attainment of that objective will be sought chiefly through a liberalization of imports.

In the remaining countries of the Region, to the exception of Argentina and Mexico, a combination of restricted domestic markets, lack of industrial experience, and low protection against imports has led to a limited development of the machine tool industry, which is often restricted to the assembly of imported parts and components.

Except for Peru, no information is available as to the cost of either imported or locally manufactured machines to users in those countries. In Peru, according to data provided by Gonzalez Roda (1990), domestic production costs are hardly competitive with import costs, to the exception of certain types of equipment (such as presses) which, as we have seen, count on a larger number of local manufacturers.

The Mexican case, and particularly that of Argentina, are perhaps representative of the worst of all worlds, inasmuch as, after a period of industrial infancy with its inevitable burden upon consumers, that process was interrupted by an import liberalization policy that led to the destruction of an industrial and technical capacity which, particularly in Argentina , was a significant one.

In Argentina, the anti-industrial trend in economic policies has been partly made up for in recent years through credit lines granted by the Banco Nacional de Desarollo for the purchase of equipment and machinery in the domestic market, as well as through fiscal incentives granted to exports. In particular, it has been partly compensated for by the signature of a capital goods integration agreement between Argentina and Brazil, which opened the Brazilian market to Argentinian manufacturers. Under the agreement, Brazil has absorbed over 50% of the Argentine machine tool exports, i.e., over one-third of the country's machine tool production in 1988 (see tables 1 and 5).

The capital goods integration agreement stands out as the major recent initiative in terms of a trade and industry policy, thus deserving to be discussed in some detail.

As originally conceived, the agreement should be a program of industrial complimentation between the two countries, based on complementation industry trade. It establishes a partial free trade zone between the two countries, circumscribed to capital goods. The universe of products embraces the majority of electrical and non-electrical machines, their parts and components, and non-automotive transportation equipment. It excludes electronic products and automotive transportation equipment, the latter being covered by another agreement which has not progressed.

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

From the signature of the agreement to this date there have been five rounds of negotiation of the common list. Within the latter there predominates non-electrical machinery produced in small batches (e.g. machine tools). Trading of parts and components is limited to a percentage of the commerce of finished products. Custom-built equipment has been excluded, pending specific negotiations, among other things, of the purchase policies regarding State enterprises (which provide the main market for such goods) and credit facilities.

As can be seen in Table 5, the capital goods integration agreement has had some remarkable results in terms of trade volume, which has increased fourfold over the period 1986-1988. The Argentinian industry seems to have benefited most by it, increasing its exports to Brazil over sixteen times. Machine tools are the main exports to Brazil, accounting for about half of the total exports under the agreement. Numerically controlled machine tools account for almost half of the total machine tools exports, consisting of models which are simpler and less expensive than the units locally produced in Brazil. Exports under the agreement have become the mainstay of the Argentinian machine tool industry, especially of its more complex products, such as NCMTs (Erber, 1989).

Table 5
CAPITAL GOODS TRADE BETWEEN BRAZIL AND ARGENTINA
UNDER THE CAPITAL GOODS AGREEMENT - 1986/88
in US$ 1,000

	1986	1987	1988
(1) Exports from Argentina			
Total capital goods	2,131	17,888	35,575
Machine tools	631	7,961	17,577
NCMTs	--	3,436	8,911
(2) Exports from Brazil			
Total capital goods	14,591	25,267	33,122
Machine tools	553	952	693
NCMTs	--	--	--
Balance (1) - (2)			
Total capital goods	-12,460	-7,379	2,453
Machine tools	78	7,009	16,884
NCMTs	--	3,436	8,911
Total trade (1) + (2)			
Total capital goods	16,722	43,155	68,697
Machine tools	1,184	8,913	18,270
NCMTs	--	3,436	8,911

Source: Secretaria de Industria y Comercio Exterior, Argentina.

As mentioned above, electronic products have been excluded from the agreement and Brazil retains its import restrictions on NC units in order to protect its infant industry. This has generated a flow of exports of those units to Argentina, which was equivalent, in 1988, to 22% of the Brazilian imports of Argentinian numerically controlled machine tools.

In spite of such results, considerable doubts remain as to the agreement's capacity to act, as it is now, as a force of transformation for the two industries.

As originally conceived, the integration agreement should provide the two industries with a widened market, ensuring static economies of scale and economies of scope and specialization, and leading to greater technological development and increased productivity on both 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.

In practice, however, the common list has so far been defined on the basis of offers from producers from both countries, reflecting their present comparative advantages. Since producers are the main negotiators and must give approval to the inclusion of products in the common list, they are in a priviledged position to avoid major competitive threats from suppliers from the other country. As a consequence, the pressure emanating from the agreement 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 will be unified, partly because both were undergoing a process of tariff reform, but at the cost of leaving the relative margins of preference undefined.

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

Given such constraints, it is possible that as soon as the obvious comparative advantages of the two sides have been included in the common list the integration agreement may loose momentum, following a pattern of early success and quick decline which has already been observed in other regional schemes of integration, such as ALALC and ALADI. Should this come to happen, a major opportunity for industrial and technological development will have been lost by the two countries.

III - TECHNOLOGICAL EVOLUTION

III.1 - Diffusion of Flexible Automation

The diffusion of flexible automation in Latin America is not proportionate to the degree of industrial development found in each national economy. In the top position, and way ahead of the remaining countries, we find Brazil, with the largest stock (approximately 5,000 units by 1988) of flexible automation equipment (FAE). Next come Mexico (1200 units in 1989) and Argentina (800 units in 1988).

At the other extreme we find the large majority of Latin American countries, the economic development of which is hardly remarkable and where either there is no diffusion whatever of such equipment or it is not statistically significant. A case in point is Bolivia, where no numerically controlled lathes can be found in use: "... the only one in the country belonged to Atlas Copco Andina, a company that was unable to sell it upon the liquidation of its assets" (Gonzalez Roda, op.cit., p. 12).

We specify below the cases of Latin American countries to whose studies we have had access, by order of importance of the diffusion of flexible automation in their respective industrial structure.

III.1.1 - BRAZIL

Flexible automation diffusion began to occur in Brazil as of the early seventies. A former study indicated that by 1980 there were nearly 700 NCMTs installed, 40% of which were lathes while 30% were machining centers (Tauile, 1984). SOBRACON statistics point to a total stock of 862 numerically controlled machine tools by the end of that year. The same source estimates that by 1989 that stock had already reached approximately 6,000 units, its evolution along the decade following the pattern shown in Table 6.

Table 6

Stock of NCMTs in Brazil in 1980-1988

Year	Stock
1980	862
1981	986
1982	1136
1983	1316
1984	1522
1985	1995
1986	3008
1987	4176
1988	4918*
1989	5970*

* Not including imports during those years.
Source: SOBRACON

The number of companies using numerically controlled machine tools, estimated at 150 in 1980, rose to 420 by 1987. Early in the diffusion process and thanks to their high prices, NCMTs were concentrated in both large corporations (above 500 employees) and subsidiaries to foreign companies, the latter bringing from their head offices the guidelines concerning the type of process technology to be used. Each of the two groups were responsible for two thirds of the

total number of units up to 1980 (Tauile, op.cit.). Although we lack more recent data, diffusion during the eighties is highly likely to have taken place mostly among small and medium size companies and among national enterprises, so that by 1984 46% of the NCMTs found in the state of São Paulo were concentrated in companies employing over 500 workers (Leite et allia, 1984).

A similar pattern of diffusion, starting with large firms and then progressing to medium and small-scale enterprises was observed on more industrialized countries as well (Chaponniere, 1990).

By 1980, 66% of the units were located in the metalworking industry (chiefly in machine tool production) and 17% belonged to transportation equipment manufacturers (mostly the automobile industry). According to SOBRACON (1989), users in 1988 also included manufacturers of electro-electronical durables, as well as steelworks and agricultural machinery producers. Whereas in a smaller proportion, the machine tool, automobile and aircraft industries still concentrated the largest number of machine tools installed in Brazil in 1988.

As in other Latin American countries (such as Argentina, for instance), the proportion of firm users owning just one NCMT unit is still rather high in Brazil. Up to 1984, at any rate, over 60% of the users could be grouped under that category.

The use of flexible automation in Brazil seems to be associated to a systematic effort to enter foreign markets. A piece of research conducted for the International Labor Organization in 1984, concerning automation in the automobile industry, showed that the autoparts manufacturers in the sample which used numerically controlled machine tools were those presenting the highest export levels (Tauile, 1987).

The same would seem to apply to industrial robots. The first of those machines to be installed in Brazil were part of an effort at modernization on the part of those automobile assemblers who decided that in the first half of the eighties they would direct a share of their production to the international market, as a means of ensuring the utilization of idle capacity in their installations, which had suffered a sharp rise as a consequence of the crisis then affecting Brazilian economy (ibid.). The total number of industrial robots installed in Brazil in 1988 (not including manipulators) reached 99 units, and their diffusion has been accelerated in the last three years, during which over 70% of that total were installed.

Although the automobile industry is still the major user of industrial robots within the metalworking complex, the utilization of this equipment has transcended that complex, so that units can also be found, for instance, in the electro-electronical industry (in the production of integrated circuits), as well as in the manufacture of leather goods, plastics, etc.

It is worth noting that the Special Secretariat for Informatics (SEI) has estimated the existence of 706 CAD/CAM units installed in Brazil, 170 of which are large size pieces of equipment (32 bits). As refers to programmable logical controllers, a consulting company has estimated that the market reached US$40 millions in 1986 and that by 1990 it should attain the US$110 million bracket (Sá, 1989). That study, made for BNDES, indicates that in 1988 a total of US$65 millions in large size digital systems of distributed control (DSDC) and of US$12 millions in small size ones were commercialized in Brazil.

According to the same study, the total demand for industrial automation equipment and services in Brazil during 1988 was estimated to range between US$374 millions (SOBRACON and ABCPAI) and US$429 millions (Sá, 1989).

III.1.2 - MEXICO

Despite Mexico's relatively developed industrial structure and although in several cases that country complements the industrial production of the U.S.A., local diffusion of NCMTs seems to be modest. According to a research work published in December 1987 by NAFINSA, who excluded the automobile industry and the "maquiladoras" from their sample, that diffusion reached the figure of 409 installed units by 1986 (Humbert, 1989). Eighty-five percent of that equipment were installed during the last ten years and 49% in the last five, which would seem to point to a slight acceleration in the diffusion of flexible automation.

Chaponniere (1990) provides an estimate for the total stock of NCMT in Mexico in 1989 in the range of 1200/1400 units (of which 50 were installed in the maquiladoras motor vehicle plants), suggesting that diffusion has accelerated further in the recent years.

Unfortunately, the only disaggregated data available refer to the 1986 situation. The distribution of the forgoing 409 units per type of equipment is shown in Table 7.

Table 7

Stock of NCMTs in Mexico

Age	Machining Centers	Lathes	Milling Machines	Drilling Machines	Boring Machines	Grinding Machines	Total
0-4 yrs.	49	103	30	4	7	8	201
5-9 yrs.	31	61	15	8	11	3	137
10-20 yrs.	9	25	0	32	3	1	70
20 yrs. +	0	0	0	1	0	0	1
Total	89	197	45	45	21	12	409

Source: Humbert, M., 1989

In any case, it may be safely stated that the importance of NCMTs is still rather scanty. Whereas they are less obsolete, they represent a mere 4% of a relatively old and modest machine tool stock in the capital goods industry (totalling 9,714 units), where machines installed over 20 years ago (which add to 1,932 units) outnumber the 1,722 units installed less than five years ago (Humbert, op.cit., p. 41).

The distribution of the NCMT stock per sector in Mexico may be seen in Table 8 below.

Table 8

Sectorial Distribution of the NCMT stock in Mexico

	Total of NCMTs	New NCMTs
Total	100%	100%
Intermediate equipment goods	19.8%	16.9%
General equipment goods	23.7%	18.4%
Steelworks	6.3%	10.4%
Transportation material	2.0%	3.0%
Autoparts	9.5%	6.0%
Electrical equipment	6.6%	5.0%
Agricultural machinery	4.9%	3.5%
Machine tools	5.9%	6.0%
Heavy machinery	6.3%	3.0%
General industrial equipment	0.7%	0.0%
Agrobusiness equipment	0.7%	1.0%
Glassworks equipment	13.2%	26.3%

Source: Humbert, M., 1989

The major users of NCMTs in Mexico are hydraulic pump manufacturers, producers of oil exploitation equipment and manufacturers of glassworks machinery. Pump manufacturers "own ...11% of the equipment in the capital goods industry as a whole" (Humbert, ibid., p. 42). That figure includes 15 machining centers which represent 17% of the total units of such equipment in Mexican industry. The hydraulic pump industry, which boasts technological standards comparable to those found at the international level, is chiefly made up of subsidiaries to American companies, from which the sector receives both the technological know-how and licensing. Their production is largely geared to foreign markets, especially through intra-company trade.

The manufacture of oil exploitation equipment is a subsector composed of both national and foreign companies, and it is outstanding for the modernity of its equipment, inasmuch as it is essential for its clients to be able to do their drilling and exploitation safely and profitably. This segment holds 16% of the total number of NCMT units

in the Mexican capital goods industry. As regards numerically controlled lathes it holds 24% of the total units of such equipment (Humbert, ibid., p. 43).

Equipment manufacture for glassworks is among the most modern Mexican industries, using equipment that is rather new and up to date. Close to 60% of its pieces of equipment have been installed less than five years ago, and again 60% of the entire equipment is made up of NCMTs. This sector holds 26% of the Mexican stock of NCMT units with less than five years of age, as well as 36% of the machining centers of the same age (ibid.). This statement actually applies to two major Mexican companies which, having started out from foreign licensing, were able not only to absorb imported technology but also to develop it according to their own specific demands. By making investments in research and development and by using advanced technology, such as CAD/CAM, they have become able to export roughly 10% of their production value, inclusive to other continents.

As mentioned above, local production of NCMTs is insignificant (only five units in 1988 and 1989). The diffusion of NCMTs in Mexico thus rests almost exclusively on imports. Since the U.S. is the main exporter of machine tools to the Mexican market (see section IV), we suppose that it is the main supplier of NCMTs, too.

III.1.3 - ARGENTINA

Between 1981 and 1988 the Argentinian stock of numerically controlled machine tools showed an increase of 229%, rising from 350 to approximately 800 units (Erber, 1989). The number of users showed a 50% increase in the same period and reached the figure of 150 enterprises. As for industrial robots, there is a total of 14 units, all of which were installed by 1988 and mostly put to use in spot welding in the automobile industry.

The use of NCMTs in Argentina is concentrated in industries producing non-electrical machinery (especially machine tools, oil exploitation equipment, and agricultural machinery) and transportation equipment (automotive and shipbuilding companies). Unlike other Latin American countries (such as Brazil), diffusion in Argentina seems to have included small and medium size companies from the outset, probably because both locally produced and imported NCMT models were simpler and less expensive (ibid.).

As in Brazil, most numerically controlled machine tools in Argentina are used as stand-alone pieces of equipment, indicating that the full exploitation of the systemic approach potential is still far off. It is estimated that less than 10% of the user firms count on more than eight machines in operation, while most users work with two or three units each (personal communication from E. Cohen, quoted by Erber in ibid., p. 26).

As equally observed in other Latin American countries (particularly Brazil, where we were able to make direct verifications in previous field research works, cf. Tauile, 1984), very few firms make a careful study of the economics involved in NCMT introduction, although suppliers do provide them with some (possibly biased) estimates.

Quality considerations and product characteristics such as the complexity of the parts produced and the strict margins of tolerance seem to represent the major reasons for the introduction of NCMTs, particularly among large enterprises (the case seeming to be basically the same in Brazil as well). Cost concerns or the reduction of idle machining time, albeit important, tend to be regarded as secondary considerations. Given the low level of wages, those cost considerations are likewise tendentially marginal in deciding upon the introduction of flexible automation.

The latest estimate of the stock of industrial robots in Argentina was of 14 units, all of them imported. They are concentrated in the transportation industry (72% of the total units). They are also found in the capital goods industry (7%), in steel production (7%), and in the electronics industry (14%). Their most common use is for spot welding (Erber, 1989).

Again as in Brazil, there is a clear connection between exports and the use of NCMTs (and robots). Production characteristics must be strictly maintained if producers are to supply international markets in compliance with international specifications. This is all the more so in the automobile and machine tool industries. External markets -- and therefore the use of flexible automation -- are progressively gaining importance due to the sluggishness of the Argentinian domestic market. Nevertheless, acceleration in the diffusion of flexible automation equipment in Argentina seems to be tied to the possibilities of recovery of the country's economy.

III.1.4 - COLOMBIA

The Colombian Federation of the Metalworking Industry (FEDEMETAL) took, in 1987, the initiative of carrying out a study on the new microelectronics-based technologies and their diffusion in Colombia. This may be a good indication of the latter's growing importance in that country. The study (FEDEMETAL, 1988) was based on research conducted in 44 companies belonging to the metalworking sector, which represent approximately 90% of the universe of Colombian enterprises which have already begun to incorporate such new technologies. Among these,

5 are users of NCMTs and computer aided design (CAD),
20 have incorporated only NCMT units,
2 are planning to incorporate both technologies,
3 plan to incorporate CAD only,
6 plan to incorporate NCMTs only, and
8 do not as yet contemplate investing in new technologies.

No robots have been installed in the Colombian industry so far, nor are there any forecasts as to their introduction, as a consequence of the fact that their cost is high (which also applies to the expected returns on the investment, if one considers the low cost of local labor) and that the functions they would perform might continue to be carried out by workers with no major loss in terms of quality. Actually, this applies to the diffusion of robots in all other Latin American countries including Brazil. Furthermore, no flexible manufacturing systems (FMS) are installed in Colombia nor does the country count on computer-integrated manufacture (CIM).

The study made by FEDEMETAL detected the existence of 61 NCMTs, 52 of which (85%) have computerized numerical control (CNC). Considering that their sample is supposed to cover 90% of the user firms (including all major ones), the universe of NCMTs in that country may be estimated not to have surpassed 70 units by the time the research was conducted. That is certainly not a large number, but the fact that such a detailed study has been conducted by local initiative shows a serious and positive attitude toward the use of this type of equipment, which seems to be gaining momentum (92% of the NCMT units registered in the study have been purchased in the last six years). The existence of an agency that catalyzes the handling and disseminate of information on new technologies should certainly favor their diffusion in Colombia, as has been the case with similar experiences in other countries (in Brazil, for instance, the Brazilian Society for Numerical Control - SOBRACON has often played an important role in the diffusion of flexible automation).

Out of the 61 NCMTs found in Colombia, 33 (54%) are lathes, 9 (15%) are milling machines, 5 (8%) are electrode spark erosion machining appliances, 5 (8%) are machining centers, 3 (5%) are boring machines, 2 (3%) are grinding machines, and among the remaining four we find 2 drilling machines, one punching machine and one emery grinding machine. Thirteen of the companies covered in the research sample had specific plans to purchase approximately 20 NCMT units, viz., 9 lathes, 8 machining centers, 2 grinding machines, and 1 milling machine. The major suppliers of imported NCMTs are the U.S.A. (36%), followed by West Germany (20%), Spain (15%), and England (8%).

The largest concentration of numerically controlled machine tools is found in the sector of transportation material and equipment, where six companies (24%) use 26 units (43% of the total), while in the metalworking industry seven companies (28%) use 16 NCMTs (26%). Another seven manufacturers of non-electrical machinery and replacement parts use 11 units (18%). The distribution of the stock of NCMTs per production sector in the Colombian metalworking industry is shown in Table 9.

Table 9

Diffusion of NCMTs per production sector in the metalworking industry in Colombia

Metalworking production sector	Number of enterprises	Total of NCMT units
Metal products	7	16
Non-electrical machinery	7	11
Electrical equipment	4	6
Transportation equipment	6	26
Control devices	1	2
Total:	25	61

Source: FEDEMETAL, 1989

The companies researched have listed the benefits deriving from the utilization of NCMTs in the following hierarchical order:

a) possibility of manufacturing new products 32%
b) increase in production volume 32%
c) higher product quality and lower control 21%
d) possibility of rendering services to other firms 15%

It is intriguing to find that in Colombia, differently from the other countries, the companies presenting the largest volume of exports are not those that use either NCMTs or CAD. For lack of more specific information we were unable to interpret this finding. It is also worth mentioning that, the rate of utilization of flexible automation equipment is generally lower than the one applying to conventional equipment. This is probably due to a lack of experience in the utilization of such technology, which is still in its early stages of diffusion.

III.1.5 - PERU

Twenty NCMTs (six of which are machining centers) are estimated to exist in Peru. All of them have been imported and installed in eight predominantly large size companies which opted for the utilization of this type of equipment owing to considerations of quality and flexibility (Gonzalez Roda, op.cit.). Speed in order delivery, thanks to an increase in productivity, and the maintenance of high standards of quality in products designed for export (for instance, mining pumps) have been additional reasons identified for the introduction of NCMTs.

The utilization of NCMTs in Peru has been growing at a slow pace, inasmuch as import tariffs (80% on machines and 125% on accessories) make them exceedingly expensive for the local user firms. The study

made by Gonzalez Roda regards the rate of diffusion in that country as a very low one, both in relation to the development level of the Peruvian metalworking industry and in comparison to other countries in the same region, such as Venezuela, Colombia and Chile.

Oddly enough, although such a small number of NCMTs are installed in the Peruvian industry, another 9 units can be found at the Leonardo da Vinci Institute (associated to the National Office for Industrial Labor Training), where they are used in technical and professional training at various levels. Those machines have been donated by the Italian Association of Machine Builders through an agreement signed with the Italian government, whereby technical advice and support are also provided for their operation. Gonzalez Roda points out that, since the agreement was drawn by that Association without any consultation to local parties, the forementioned training center is now underutilized. This point is worth noting inasmuch as a similar agreement was signed in Brazil with the local National Office for Industrial Training (SENAI). Owing to the resistance put up by Brazilian machine tool manufacturers, who viewed that initiative as a marketing manoeuver, the training center in question was not installed in São Paulo, the country's major industrial pole, but rather at the SENAI installations in Rio de Janeiro.

Unfortunately, we have been unable to gather data on the diffusion of flexible automation equipment in Chile and Venezuela, which seem to form with Colombia (and in a smaller scale, also with Peru) an intermediate subgroup of countries where that diffusion, albeit still rather small, may indicate the beginning of a change in the technical basis of the more dynamic sectors of their local industry.

III.2 - Local production of flexible automation equipment

Local production of flexible automation equipment in Latin America is almost exclusively restricted to Brazil and Argentina (the latter in a far smaller proportion).

III.2.1 - BRAZIL

III.2.1.a - Numerically controlled machine tools

The manufacture of the first NCMTs for industrial use occurred in Brazil in 1975 and was carried out by the leading national producer of machine tools, who adapted a numerical control cabinet to a conventional piece of equipment. Shortly afterwards, some subsidiaries to German companies also initiated their local manufacture of NCMTs. Most of these firms were then just recently installed in Brazil in compliance with the local government's plans for enhancing the process of import substitution by generating local capacity for the production of capital goods.

Foreign subsidiaries used to bring in from their parent companies the entire product and design technology, which was usually outdated by

one or two models as compared to the units manufactured by their head offices abroad. Whether this was a coincidence or not, the products offered by those companies were different from one another and there was no competition among them. As for the two major Brazilian-owned companies which started manufacturing NCMTs as of the second half of the seventies, both ended up choosing to manufacture similar lathes under foreign technology licenses obtained from the same Italian enterprise. By 1980, out of the 700 NCMTs in use, 130 had already been produced in Brazil. As shown in Table 10, the number of NCMTs produced per year, increased six-fold over the eighties. In the last four years of the decade, yearly production averaged 911 units, and the stock came close to six thousand units in 1989. During the same period, as a result of import restrictions, and of expansion of local production, the import coefficient fell from 64% in 1980 to 13% in 1987 (last year available).

Table 10

NCMT Production, Imports and Stocks in Brazil (per units)

Year	Production	Imports	Total	Stock	Import Coefficient
up to 1979	110	274	384	384	71.3
1980	172	306	478	862	64.0
1981	69	55	624	986	44.3
1982	120	30	150	1,136	20.0
1983	150	30	180	1,316	16.7
1984	153	53	206	1,522	25.7
1985	413	60	473	1,995	12.7
1986	833	180	1,013	3,008	17.8
1987	1,018	150	1,168	4,176	12.8
1988	742	n.a.	n.a.	4,918*	n.a.
1989	1,052	n.a.	n.a.	5,970*	n.a.

* Not including imports during those years.
Source: SOBRACON

Sales of locally produced NCMTs reached US$224 millions in 1989, the evolution of the corresponding revenues between 1986 and 1989 being as follows:

Table 11

Sales of NCMTs (US$ millions)

1986	187
1987	197
1988	223
1989	224

Source: SOBRACON

No data are available regarding the distribution of the installed NCMTs according to the types of machines. An approximate indication of that distribution, however, is the sales proportion for 1987, when 62% of the units were composed of lathes and 10.7% were machining centers. In terms of value, the proportions were respectively 55.1% and 23.3% (Laplane, 1989, based on data from ABIMAQ).

There currently exist ten local manufacturers of machining centers which supply the market with 41 different models. Only two of these have chosen to develop their own technology. Another seven producers decided in favor of licensing, and one adopted a combined strategy. In terms of CNC lathes there are six manufacturers also producing 41 different models, while eight companies manufacture 36 different models of CNC milling machines (ibid.). Generally speaking, the local companies have opted for using licensed technology in the manufacture of their NCMTs, there being some eventual local technological development. The Brazilian-owned companies which count on more abundant resources are the ones that have been more capable to opt for a strategy of full development of their own design for certain products. In some cases these firms benefited from Government loans for technological development.

Subsidiaries to foreign companies generally manufacture more sophisticated NCMTs than national enterprises. As indicated in the first section of this report, foreign subsidiaries operate with technology supplied by their parent houses, but some local technological capability has had to be developed in order that they might cope with the adaptation of their products to locally supplied CNC units and other electronic devices.

Despite its relative success, the production of NCMTs in Brazil suffers from a serious drawback. The cost of this equipment tends to be two to three times above international market prices for equivalent models (in view of which there are no NCMT exports in Brazil). A simple comparison with the NCMT units manufactured in Argentina, where the average cost in 1988 was in the order of US$124,000.00, shows that the equipment manufactured in Brazil in 1989, albeit more complex, had a average cost almost twice as high as that (US$213,000.00).

The small scale of production is often pointed out as the major hindrance to a reduction of costs in the sector. In fact, an estimate made by the Boston Consulting Group (quoted in Chudnovsky, 1988) indicates that the economic scale for the manufacture of NC lathes corresponds to 400 units per year, a figure which is far above the level attained in Brazil, where total production reaches about 1000 units/year, so far.

Demand instability, chiefly provoked by the Brazilian crises of the eighties, is an additional aggravating factor commonly quoted as impeditive of the investments required to reduce costs, inasmuch as it obscures the parameters utilizable in the corresponding economic calculations. A recent research work based on interviews with a

representative sample of local machine tool manufacturers showed that the high level of vertical integration observed in Brazil is not regarded as a source of high costs, contrary to what the current literature would seem to suggest (Laplane, 1989).

A further major reason for the high costs lies in the local supply of raw materials and components. As shown above, in Table 4, most parts and components locally produced cost substantially more than imports, specially those used for NCMTs. However, in the recent past the discussion about the cost of NCMTs has focused on electronics components, specially CNC units, partly because electronics are an important item in the cost structure of an NCMT, and partly because CNC units were placed under market reserve conditions by the informatics policy. Therefore it is convenient to examine Brazilian CNC production in more detail.

Until the early eighties, numerically controlled cabinets used to be imported. As of 1982, SEI instituted a market reserve for the production of CNC cabinets with a view to generating industrial and technological capabilities through the purchase of foreign technology and its subsequent local development. As can be seen in Table 12, the number of units manufactured, reached 1124 in 1989 (from 253 in 1984). Sales value in the period 1986/89 ranged around US$ 20 million, except for 1988 when they dropped to US$ 14 million.

An estimate of revenues by the various segments of the electronics complex involved in industrial automation may be seen in Table 12.

Table 12

Revenues by segments concerned with industrial automation in the Brazilian electronic complex
in value (US$ million) and units

	1987		1988		1989	
	Value	Unit	Value	Unit	Value	Unit
PLC	34.0	--	51.3	--	65.1	--
NC/CNC*	20.0	1,138	13.9	816	20.1	1,124
CAD/CAM	29.0	611	36.0	700	99.3	2,658
Robotics	5.1	28	2.0	12	1.4**	7

* CNC production, in units, was 253, 413 and 757 in 1984, 1985 and 1986, respectively. The value in 1986 was US$ 22.2 million.
** US$4 millions, if robot systems are included.

A major characteristic of the Brazilian supply of CNC cabinets is its segmentation. Out of the seven suppliers, three are captive to local producers of machine tools - one to the leader of the industry, the second to a medium sized producer of grinding machines and the third operates under an OEM agreement with one of the main producers of

special machine tools, a German subsidiary. 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 beginning was virtually non-existent, since one of them had the technology suited only to milling machines, leaving the other entreprise with the virtual monopoly of the merchant market. The two firms operated with licenses from foreign companies which previously supplied the Brazilian market directly through local subsidiaries.

Such monopoly was successfully challenged in 1984 by a relatively small electronics firm which introduced a much simpler and less expensive system based on in-house development. 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 its competitor, which is still the main firm in terms of sales value, has introduced simpler models. Since the latecomer is upgrading its product range, competition is increasing in the middle range of the market.

Competition has also increased in the higher end of the market. The firm which had a license for CNC for milling machines, dropped the contract and started to manufacture a unit that can be used to control both NCMTs and industrial robots. In 1988, a leading firm from the programmable control (PC) market started producing a sophisticated CNC unit based on PC technology.

Therefore, Brazilian producers of CNC 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).

According to the estimates of Erber (1989, p.15), "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. ...Over half of the CNC units were internally designed. Since such products tend to be simpler than the licensed units, their share of the value of production is only one-fifth of the total".

Brazilian users have complained about the difficulties of importing CNCs and the high cost of substitutes. Nonetheless, in a recent interview the president of ABIMAQ has acknowledged that import restrictions to products which have no domestic similars 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.

In an unpublished study, reported by Erber (1989), SEI has compared prices of Brazilian-made products with foreign equivalents. It

shows that the FOB prices of Brazilian-made CNCs dropped sharply from 1983 to 1986 and increased again in 1987, due to the introduction of new models and exchange fluctuations. The differential between prices of Brazilian-made products and their equivalent abroad dropped from 1.94 times in 1983 to 1.63 in 1987.

The price differentials are not the same for products locally designed and licensed: in 1983, the former costed 1.46 times the foreign equivalent, and in 1987 were about the same price. The licensed products started the period with a price 2.24 times higher, and maintained such difference, increasing it in the last year to 2.72.

Several factors may explain the high cost of Brazilian CNCs. In the first place, the scale of production is small compared to international standards. The world leader of the industry - Fanuc- is reported to manufacture 4,000 units per month (Chudnovsky, 1988). Other important international suppliers in the U.S. and in Europe, produce about 1,000 units per year. This order of magnitude is reported as desired by Brazilian manufacturers in interviews with Laplane (1988). Presently the two largest merchant suppliers produce in the range of 350 to 450 units per year.

Scale economies affect not only fixed costs, but also the costs of components, both local and imported. The former are expensive because of their are produced in small scale too, and the latter are burdened by diseconomies of small bath purchases.

Thirdly, local production of CNC is still in its infancy stage with all the general inefficiencies that go with that stage. Finally, it is probable that the limited competition established by the combination of import restrictions and market segmentation, has warranted high mark-ups for the locally established producers.

Local users consider the quality of the products good and are satisfied with the technical assistance received (Laplane, 1988). Such factors coupled to the mastery of design skills, and to the reduction in prices indicate that a strong learning process is under way in the Brazilian CNC industry. Given the short life of the policy and the pervasiveness of high price differentials to imports, which includes products that are not under the market reserve policy, to indict the latter on the basis of the CNC costs is hazardous.

III.2.1.b - Industrial Robots (IRs)

IRs were first introduced in Brazil in 1983 via imports made by the automobile industry. By the end of 1984, 26 multifunctional programmable IRs had been imported (21 of them having been brought in by the automobile industry), and demand projections were optimistic. Investments in the installation of IRs were expected to reach about US$80 millions between 1986 and 1990 (corresponding to 500 units).

In view of those optimistic expectations, in December, 1984 SEI invited locally-owned firms to submit projects for the production of IRs. A total of over 20 proposals were submitted in the following year. Seven manufacturing projects were approved by SEI: three of them covered multifunctional IRs based on licenses from abroad, while four simpler IRs were based on local design. Nine projects for product development were equally authorized, two of them concerning electronic control systems.

With the general reduction of investments in the economy, especially in the automotive industry, demand had a far lower increase than expected. Manufacturers of multifunctional IRs sold 35 units over the period 1986-1988, and sales declined over the last two years.

Table 13

Industrial Robots in Brazil
Number of Units and Sales Value (US$1,000)

	Total		Programmable	
Year	Number	Value	Number	Value
Up to 1985*	26	n.a.	2	n.a.
1986	33	2,900	-	-
1987	28	5,100	26	1,197
1988	12	2,085	9	1,643

Notes:
(*) Includes imports. Data for 1986-88 refers to local production only.
(**) Sales value net of taxes.

Sources: TOTAL IRs - Up to 1985 -- Sa (1989)
1986-1988 -- SOBRACON (1989)
PROGRAMMABLE IRs -- SEI (1989)

IR production in Brazil is very segmented. As formerly pointed out, a first group of firms produce multifunctional units based on foreign licensing. One of the four originally approved manufacturers has since left the market, and competition between the three remaining firms is limited, owing to the differences in the products they supply (for instance, only one of them has a model that is suited to spot welding, which is the main IR application in Brazil).

As a consequence of the forgoing combination of restricted demand and product specialization, the companies' sales have been very irregular. The forementioned manufacturer of IRs for spot welding sold 23 units in 1987, but not a single one in 1988. As for the other two, one firm sold the first seven units in 1988 and the third producer sold two units in 1987 and an additional one in 1988.

A second group of manufacturers composed of about eight potential robotics suppliers developed their products locally. The latter are much simpler than the products manufactured under license (incorporating, for instance, fewer degrees of freedom and a more limited lifting capacity) and are mainly suited to manipulating activities such as pick and place, machine loading and handling of materials.

Approximately half of those firms have followed a strategy of designing standard IRs, while the other half have preferred to supply custom-made equipment. The latter has the advantage of reducing risks and increasing the joint development of application technology by users and producers. Although this strategy seems to be marginally more successful, only a small number of firms in this second group have actually implemented their product development programs and have been able to sell their industrial robots.

Although two firms did obtain approval from SEI for their projects to supply electronic and mechanical components, the imported content of locally-manufactured IRs is still high and tends to remain so in view of the small scale attained.

Licensors have provided their Brazilian clients with training on 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 resort to licencing have relied mainly on the technological capabilities developed in other lines of production.

While no price comparisons between Brazilian made robots and their imported equivalents have been made available to us, the former are very likely to be considerably more expensive than the latter. The reason for this is that adding to the scale effect, there are also learning costs and the investments which Brazilian companies have had to make in manufacturing, design, and training.

III.2.2 - ARGENTINA

Despite a dramatic reduction in the local production of machine tools (from 22.500 units in 1973 to 5.600 units in 1988) as a consequence of the deindustrialization process that has taken place in Argentina, the last few years have witnessed some growth in the production of NCMTs in that country. This increment has resulted largely from exports due to the capital goods agreement signed between Brazil and Argentina and referred to earlier on, in this report.

As mentioned above, three nationally-owned companies are responsible for virtually all of that production. Two of these, produce 90% of the country's NC lathes. One of these firms also manufactures machining centers (and it is the only one to do so). A third, and smaller enterprise, manufactures numerically controlled milling machines. Though they all operate under licenses from foreign

companies, those enterprises have a considerable design capability. Two other local manufacturers of conventional lathes have begun to produce some NCMT units, if only sporadically.

Local production of NCMTs, initiated in 1979, had reached roughly 100 units per annum in 1987-88. At the close of 1988 the installed stock is estimated to have attained approximately 800 units (Erber, 1989). Table 14 shows the evolution of local production as well as NCMT exports and imports from 1985 through 1988. It should be noted that the large majority of NCMT imports during that period covered lathes (40%) and milling machines (37%).

Table 14

Production, Exports and Imports of NCMTs in Argentina per Unit and Value (US$1 million), 1985-1988

	1985	1986	1987	1988
1. Production:				
Units	16	34	100	96
Value	1,27	3,36	10,21	11,93
2. Exports:*				
Units	1	5	38	77
Value	0,50	0,27	3,96	9,59
3. Imports:				
Units	28	33	31	40
Value	4,23	3,88	4,60	9,01
4. Apparent consumption:				
Units	42	62	93	59
Value	5,44	6,17	10,85	11,35
5. Export coefficient (2)/(1) (%):				
Units	6.70	14.70	38.00	80.20
Value	39.40	8.00	38.70	80.40
6. Import coefficient (3)/(4) (%):				
Units	66.70	53.20	33.30	67.80
Value	77.70	55.70	42.40	79.40

* - lathes only
Source: Chudnovsky (1990)

There is no production of industrial robots in Argentina. As a matter of fact, local production was limited to a prototype for training, which had dimensions and lifting capacity unsuited to industrial applications (Erber, 1989).

It may be observed that in 1988 exports represented about 80% of the total Argentinian production of NCMTs. In 1987 and 1988, NCMT exports represented close to 30% of the country's total exports of machine tools. Exports of CNC lathes alone amounted to 24.7% of the total MT exports in 1987 and 29.4% of the total for 1988 (ibid.). Virtually all exports of CNC lathes were made to the Brazilian market, where they attained a significant proportion: approximately 12% of the units of CNC lathes manufactured in Brazil and 7% of their value. This point will be seen in further detail in Section IV.

III.3. The use of flexible automation in the machine tool industry

The material we were able to gather about the use of flexible automation in the machine tool industry in Latin America refers only to the Brazilian experience.

As formerly stated, both the diffusion and production of NCMTs in Brazil were initiated in the early seventies. It was found that by 1980 at least "87% of the users -- of about 700 units -- might be classed as belonging to the capital goods producing sector" (Tauile, 1984, p. 62). In those days, the machine tool sector is highly likely to have been the major user sector of such equipment in Brazilian economy. Its leading firm itself owned approximately 10% of all NCMTs installed in the country.

That early diffusion pattern made sense inasmuch as the import substitution policy in Brazil was then under expansion, new investments being made particularly in the capital goods sector, which in turn gave support to some large state investments in the country's infrastructure and to the expansion of the automobile industry's capacity.

On the other hand, NCMT diffusion in advanced countries was entering a new stage of acceleration on account of the development of computerized numerically controlled (CNC) cabinets, revolutionizing in the international production of machine tools. That was not merely an additional breakthrough in the industry. Given their operational characteristics, which are suited to production in small diversified batches, with great precision in performance and operation repeatability, NCMTs find a natural utilization precisely in machine tool manufacture. With the advent of flexible automation, the producers of standard universal equipment whose economic development depended upon the attainment of certain minimum scales began to increase their efficiency also in the production of both smaller batches and even custom-made ones. That flexibility was further augmented by the utilization of CAD technology, which greatly expedited design activities, and by the introduction of new organizational conceptions inspired by the systemic view of the productive process.

Considering that picture, the continuity of technological evolution in the Brazilian machine tool industry in the early eighties depended upon the maintenance of the local economy's growth impetus. And that was precisely what did not happen. After five decades of high growth rates (averaging about 7% p.a.), Brazilian economy went through

a sharp deceleration in the early eighties, with some direct effects on industrial production, which has remained virtually stagnant ever since. Automobile production, for example, dropped by one third between 1980 and 1981 -- from nearly 1,2 million vehicles down to less than 800 thousand --, and despite a gradual recovery along the decade it never recovered the 1980 level of production.

Immersed in the foreign debt crisis and in a crisis of credibility affecting political authorities, both of which put the country on the verge of hyper-inflation, Brazilian economy lacked any sound prospects that might allow for the economic calculations required for investing in the expansion of its productive capacity. Moreover, Latin American countries, which provided the main markets for Brazilian machine tool exports in the seventies, were likewise subjected to a severe contraction in the early eighties. The combination of such factors had a strong negative impact on investments in that industry.

Growth expectations in the NCMT market in Brazil, which had gone so far as to encourage two German companies to start producing numerically controlled cabinets locally, were utterly thwarted. As a consequence, during the eighties, purchases of NCMTs were not for expanding capacity strictu sensu, but rather for defensive adjustments in the productive apparatus, with a view to ensuring better performance in a market that was becoming unstable. Such investment did, however, mean increasing productivity, particularly when firms geared part of their supplies to some new external markets that seemed to offer a convenient alternative to the declining domestic market.

With the balking of most expectations of larger investments in the economy, the investments made by machine tool manufacturers were likewise stalled. The external market did not present a viable alternative for three complementary reasons. To begin with, embeded in a widespread crisis then affecting Latin American countries, the Mexican market, which was the main destination of Brazilian exports, had a severe contraction and geared its import sources to the U.S.A., as will be seen ahead. In addition, substantial investment was required in order to fit into the productive and technological revolution that the industry underwent internationally. This restriction was further aggravated by the constraints imposed by the government policy aimed to ensure the manufacture of numerically controlled cabinets by Brazilian-owned companies.

As a consequence, by 1985, machine tool production in Brazil was only 30% of the 1979 level (respectively 22,000 and 73,000 units produced), and began to recover only in the second half of the decade, albeit partially, since in 1988 it produced 34,000 machines, less than half of the 1979 level.

The drastic market reduction, above described, prevented the Brazilian firms from reaping static economies of scale at the time that several of them had just completed productive capacity expansion, which they had started during the second half of the seventies. The crisis led also to losses of specializations and thus of economies of scope

and learning, since the firms had to produce whatever the shrunk market would buy.

Therefore, the local machine tool industry had no means of keeping pace with the investments in the modernization of process technology that were being made abroad, either in the spheres of production or design. A study conducted at the request of the Science and Technology State Department in São Paulo declared that "the technological gap in the area of machine tool manufacture is associated with automation in planning and production and also with manufacturing precision and productivity" (Laplane, op.cit., p. 24). The same study emphasized the technological gap in the sphere of mechanical design for national equipment: "... as a rule, the design of machine tools in the country is based on simplified calculations and empirical trial-and-error methods coupled with experimental verifications" (ibid., p. 25). As an indication of that technological gap, the study in question pointed to "the low diffusion of design automation systems and computerized systems for production planning and control, as well as the low diffusion of automated equipment in manufacture" (ibid.). The lack of an adequately consolidated components industry (responsible for an exceedingly verticalized organizational structure among manufacturing companies), the low level of sophistication attained by many users, and the scarcity of skilled human resources were equally pointed out as obstacles to modernization in the sector.

The technological gap was acknowledged by producers themselves. In fact, most of them had plans for investments in modernization, but went on postponing them while awaiting a clearer definition of the long-term economic outlook for Brazil. Nonetheless, over the last two years, some of the leading firms have made substantial investments in productive and technological capability.

Another study (Fleury, 1988) concerning the impact of microelectronics on the Brazilian metalworking industry has yielded some important results connected with the modernization of machine tool production. Fleury's study makes a distinction between modernization achieved through the introduction of new physical technologies, and modernization attained through the implementation of new organizational techniques, correctly asserting that industrial production may be modernized without the use of microelectronics.

Grounded on the theoretical references developed by Raphael Kaplinsky (1984), who identifies an integrated or non-integrated automation process in three different spheres in production (coordination, design and manufacture), Fleury distinguishes three modernization strategies defined as follows:

"Systemic: (a strategy) that aims at the firm's informatization, flexibility and integration through the adoption of quality programmes, techniques of group technology, cellular manufacture and just-in-time, whether or not this is assisted by systems of computerized information. In the same way, there may or may not be an acquisition of microelectronic equipment in the manufacturing and design spheres;

"Partial: (a strategy) based on the acquisition of microelectronic equipment as a priority, with no greater efforts in terms of the firm's reorganization;

"Conventional: ... firms that are investing neither in equipment nor in reorganization" (Fleury, 1988, p. 17).

Fleury's research sample included sixty-one companies, twenty of which were machine tool producers while eighteen manufactured autoparts. Out of the former, eleven were Brazilian-owned enterprises and nine were subsidiaries to foreign companies, mostly German ones. Among the former were included the leading producer of machine tools in Brazil (with 21% of the sector's employment and 13% of its production value) plus one medium- to large-size company and other nine firms with less than 500 employees each. The four leading companies in this group composed a subgroup whose common trait lay in their regular exports of over 10% of the total production value. Among the foreign subsidiaries -- whose chief market was the automobile industry -- there were companies of all sizes, ranging from one which employed 1,000 workers to a firm whose operation consisted of manufacturing technologically sophisticated equipment made to order on a unit-by-unit basis, and assembled from subcontracted parts and components.

Fleury found a relatively small number of machine tool producers who had opted for the systemic modernization strategy -- in fact, two companies only, against eleven enterprises in the sector of autoparts, for example. Twelve of the remaining companies adopted the partial modernization strategy and six were conventional firms.

With reference to machine tool production, the study reports "different intensity in the usage of microelectronics in production. For example, there is a Brazilian firm with more than 100 NCMTs linked to a CAD system; meanwhile, a subsidiary firm uses more than 20 NCMTs with no CAD linkage. The remaining firms in the sector, including subsidiaries, have an average of four NCMTs in production and only two firms have small CAD systems" (ibid., p. 29). In one of the companies there was an unmanned automated cell, a second one having been found in the production of autoparts.

According to Fleury, the chief motive for modernization among the leading national companies had been the wish to maintain their competitiveness in the international market as back in the seventies. Within that context, "efforts at automation and modernization by the leading (NCMT producing) firms are fundamentally motivated by both competitiveness of machine tools in the internal market and maintaining competitiveness of conventional machines in the external market" (ibid., p. 32). Anticipation of a probable import liberalization seems to have accelerated this process, leading to the introduction of new lines of products and new plants (M. Laplane, personal information).

Concerning German subsidiaries, group technology was identified as the only organizational innovation implemented. It is important to note that "this organizational technique was not developed in the

Brazilian subsidiary but already comes incorporated in product designs which are sent by the parent company. At the same time the use of microelectronics equipment in production is relatively limited when it exists at all" (ibid.). Such a defensive attitude on the part of German subsidiaries is presumably associated with three sources of uncertainty: the instability of Brazil's political and economic situation; the uncertainty about long-term investment projects in the automobile industry; and the import restrictions created by the Informatics Act.

With respect to the group of smaller nationally-owned manufacturers, their principal reasons for making some minor investments in microelectronic technology were reported to be:

-- the need to seek solutions to reduce costs, improve product quality, and shorten delivery terms to clients in view of the rising competition among those Brazilian companies which had specialized in conventional machines;

-- the demand made by the machine tool market for manufacturers to modernize their companies (customers are eager to know whether the production technologies used in the equipment they purchase are up to date);

-- the fact that the pressure for producing NCMTs requires learning the corresponding design and development activities, which in turn can only be done through the use of microelectronics in the production process.

Generally speaking, the major results achieved through microelectronic automation are reported to be, in that order: an improvement in product quality, greater control over the production process, and increased process flexibility. Nevertheless, all of the companies that had no microelectronic equipment at the time Fleury's study was conducted, but which were planning to purchase it, rated the increase in production control as foremost among the results sought after. This probably indicates a misguided assessment for more effective production planning and control do not necessarily result from the installation of microelectronic equipment. It is further worth noting that the questions pertaining to labor always ranked last among the priorities listed by the companies in the research sample for their automation.

It is likewise interesting to note the evolution of employment in the Brazilian machine tool industry between 1980 and 1988, as well as the evolution of the corresponding associated labor categories and the changes observed in the structural composition of the labor force (Tables 15, 16, and 17).

Table 15

Evolution of Total Employment in the Production of Machine Tools in Brazil, 1980-1986

Year	Total	Variation (%)	Index
1980	18.883	-	100
1981	14.521	-23	77
1982	10.782	-26	57
1983	9.045	-16	48
1984	11.519	27	61
1985	14.785	28	78
1986	17.299	25	92
1987	13.560	-22	72
1988	15.724	16	83

Source: ABIMAQ

Table 16

Evolution of Employment per Associated Labor Category in the Brazilian Machine Tool Industry, 1980-1986

	1980	1981	1982	1983	1984	1985	1986
Direct labor	100	63	56	54	83	97	116
Production technicians	100	100	84	79	152	194	226
Design workers	100	87	87	90	109	136	176

Source: Fleury, 1988

Table 17

Changes in the Labor Force Structural Composition in the Brazilian Machine Tool Industry, 1980-1986

	1980	1986
Direct labor	90.3	85.2
Production technicians	3.0	5.1
Design workers	6.7	9.7

Source: Fleury, 1988

We may gather from the forgoing tables that in the beginning of the recessive period experienced in the first half of the eighties, the employment of direct labor was the one to suffer the hardest blow. Fleury maintains that, faced with the adverse conditions then prevailing in the market, local companies reacted by seeking both a greater rationalization in the productive process and new markets and products
-- a reaction that is likely to have implied an intensification of engineering activities, a higher frequency of the set-up activities, and a growing concern over maintenance. Despite a partial recovery in direct labor employment in the years following 1983, the industry's occupational structure underwent a gradual change towards favoring the employment of better skilled workers, particularly in the design area.

Perhaps the most interesting results yielded by Fleury's study as far as the present report is concerned have to do with the variation in the companies' employment volume in face of the oscillations in economic activity that took place during that period, given the modernization strategies adopted: "... in the case of the machine tool firms, at the end of 1983, those firms using a partial modernization strategy employed 30% less personnel than in 1980; in contrast, those firms using a conventional strategy employed 49% less. At the end of 1986, those modern firms already employed 33% more than in 1980, while conventional strategy firms employed 2% more than in 1980. (...) Through this analysis, it is clear that those firms using the partial modernization strategy dismissed fewer workers during the recessionary period and employed more people and more quickly during the recovery period" (ibid., p. 46).

With regard to the autoparts sector, Fleury found that the companies which adopted the systemic strategy dismissed fewer workers during the recession and were better able, when economic activities picked up once again, to hire a larger number of workers at a faster pace than the firms that had adopted a partial modernization strategy.

The author concludes from his sectoral studies that, in general terms, those companies which advanced further towards the systemic strategy in their modernization process were the ones to present a better performance, both in terms of productivity and employment generation. He also concludes that the modernization strategy adopted by a given company depends upon its managerial capacity, for if modernization is ultimately independent of the introduction of microelectronic equipment, it is basically dependent on a new organizational philosophy and on new operational procedures.

The results above suggest that technological heterogenity is increasing within the Brazilian machine tool industry. Since the present government intends to progressively reduce protection against imports over the next few years, it is probable that a major restructuring of the industry will follow suit.

IV. INTERNATIONAL TRADE

International machine tool trade is very dynamic and has been growing at rates that surpass the general average prevailing in world trade at large, as shown in Table 18.

Table 18

GDP and MACHINE TOOL IMPORTS FOR ALADI AND THE WORLD
(US$ Millions)

Years	GDP (1) ALADI	GDP (1) World
1980	573*	11,939
1981	668*	11,834
1982	681	12,860
1983	587	12,883
1984	626	13,373
1985	630	13,854
1986	642	16,624
1987	-	18,143

Years	IMPORT (2) World	Machine tools ALADI (A)	Machine tools World (B)	Rate (%) A/B	Rate (%) B/C
1980	1946	0.859	9.662	8.89	0.50
1981	1929	0.869	9.665	8.99	0.50
1982	1807	0.628	8.072	7.80	0.44
1983	1751	0.323	6.766	4.77	0.37
1984	1867	0.311	7.012	4.45	0.37
1985	1881	0.281	8.758	3.21	0.47
1986	2061	0.346	10.727	3.22	0.52
1987	2424	0.411	13.010	3.15	0.54

(*) Exclusive Argentina
(**) Argentina, Brazil, Chile, Colombia, Mexico, Peru, Uruguay, Venezuela.

Source: (1) IFS (1988); (2) INTAL, from Chudnovsky (1990), and FUNCEX, Balança Comercial (1989).

As we have pointed out earlier, the manufacture of machine tools in Latin America occupies a marginal position within the international context, answering for less than 2% of the international production levels. In all Latin American countries except Brazil (where local production supplies over 80% of the market), imports are the major source of machine tool supply, accounting for at least three-fourths of the apparent consumption in Argentina and for about 90% of it in the remaining countries (see Table 1, Section 1).

Considering this picture, it is alarming that, while the international imports of machine tools have increased from US$9.6 thousand millions in 1980 to US$13.1 thousand millions in 1987, Latin American countries should have reduced their machine tool imports in the same period to less than one half of their former volume, i.e., to US$411 millions in 1987 against US$859 millions in 1980 (see Table 18). In other words, the region has reduced its participation in world imports from 9% to 3%.

The general contraction of Latin America's gross income has certainly contributed to the decline in the participation of the region's machine tools imports in international trade: the aggregate gross national product (GNP) for Latin American countries in 1986 could not even match the levels attained in 1982, in contrast with an increasingly expanding international GNP (which showed a growth rate above 50% in the period 1980-1987).

From the structural point of view we note that Latin American imports are concentrated in a very few countries. Mexico, which supplies over 90% of its internal market with imported machine tools, has represented nearly one third of the region's total imports in the period 1983-1987, followed by Brazil with a share of 19% (see Tables 19 and 20).

In the forementioned period, the major single supplier of machine tools to Latin America were the U.S.A. As Chudnovsky (1990) has pointed out, although the machine tool sector in the United States has been undergoing a crisis and loosing ground in the international market, nearly one-fourth of the units imported by ALADI in 1983 came from the U.S.A., and by 1987 the latter's participation had increased to 31%. Therefore, even though a contraction in machine tool imports may be observed in Latin America, the U.S. have managed to expand their sales from US$78.3 millions in 1983 to US$128.7 millions in 1987. This result was chiefly due to the behavior of the Mexican market, which absorbed 62% of the American machine tool exports to the region during 1983-1987. In Mexico, the participation of imports from the U.S. in the country's total machine tool imports has raised from 23% in 1983 to 62% in 1987 and has doubled its value.

Brazil and Argentina, however, have contradicted that tendency and reduced their machine tool imports from the U.S.A. in favor of machines manufactured in West Germany. Out of the total Brazilian machine tool imports in 1983, 27% were of German origin, and such share rose to 41% in 1987. A similar process has taken place in Argentina. The reduction of their machine tool imports from the U.S.A. (from 18% in 1983 to 6% in 1987) was compensated for by the acquisition of MTs imported from Germany, which represented 16.5% of the total MT imports in 1982 and rose to 24% in 1987 (see Table 20).

We must also draw attention to the high percentage of imported Italian machine tools in the region (11% of the total in 1987), which was higher than the Italian participation in the industry's exports (8%

in 1989, as reported by Chaponniere, 1990). The major exception to that supplier's penetration is the Mexican market, where Italian machines represent less than 4% of Mexico's imports.

Conversely, there is a remarkably low participation of Japanese suppliers in the Latin American market, as compared to their international significance.

It should finally be noted that Brazil, the region's major manufacturer (with over 80% of the machine tool production in Latin America), answers for less than 2% of the area's imports. Argentina, whose production in terms of value is inferior to one-tenth of the Brazilian one, accounted for roughly 0.7% of the imports made by the region during 1983-1986 and increased its participation to 3.6% in 1987, thanks to sales made to Brazil under the terms of the Capital Goods Integration Agreement signed between the two countries (and formerly referred to in this report).

The specificity of the supply of machine tools in Latin America, as regards supplying countries, cannot be explained solely on the basis of commercial factors. American hegemony in the Mexican market, for instance, is strongly affected by other economic relations that link those two countries, especially by direct American investments made in Mexico and by the industrial subcontracting practices that prevail between American and Mexican enterprises. The weight of German sales in Brazil and that of Italian sales in Argentina is also likely to be influenced by the role played in each of those countries by direct German and Italian investments in sectors demanding machine tools. Regrettably, no information is available regarding the credit lines granted either by suppliers or by official agencies in charge of promoting exports from more industrialized countries, so that we have been unable to assess their impact on the orientation of Latin American imports, which, supposedly, should be quite substantial. The influence of the forgoing factors would require an investigation in further detail.

Along the same line of considerations, it seems worthwhile to stress the influence exercised by the Brazil-Argentina capital goods agreement on the increased participation of Argentinian machine tools in Brazilian imports of such equipment.

The available statistical information regarding the type of machines that are imported is inadequate. However, the data presented by Chudnovsky (1990) concerning most countries in the region reveal a wide diversification of machine types -- a finding that comes as no surprise in view of the local industry's insufficient development. The major exception seems to be Mexico, where 64% of the imports made in 1987 were concentrated in lathes (ibid).

With respect to Brazil, roughly three-fourths of the imports made in the period 1978-1988 covered metal cutting machines. In the last few years (1986-1988), however, there has been an increase in the participation of forming machine tools, which have substantially higher import/apparent consumption coefficients than those applicable to metal cutting machines (see Tables 21 and 22).

TABLE 19

MAIN MACHINE TOOL SUPPLIER COUNTRIES TO ALADI - 1983-1987
(US$ million)

IMPORT./YEAR		WORLD	U.S.A	FRG	ITALY	JAPAN	SWITZ	SPAIN	ARG.	BRAZIL
	83	170,8	39.4	30,1	5,4	9,3	1,0	7,6	0,2	0,6
	84	178.3	55.6	18.1	1.9	18.4	3.5	4.4	0.4	3.2
MEXICO	85	149.7	50.4	33.0	4.8	30.3	5.3	7.8	0.8	2.1
	86	177.3	114.8	23.9	5.3	1.4	3.0	6.3	0.4	0.8
	87	126.4	78.1	23.3	4.7	6.7	4.3	1.9	0.1	0.6
	83	65.0	18.5	17.7	6.5	13.8	2.8	0.4	0.0	0.0
	84	42.3	13.3	7.0	16.3	2.7	1.0	0.3	0.1	0.0
BRAZIL	85	36.3	9.7	15.1	1.9	2.8	2.7	0.3	0.2	0.0
	86	60.0	9.8	23.7	5.4	9.0	6.1	0.4	0.7	0.0
	87	120.1	18.7	40.9	13.3	13.6	5.8	2.5	11.4	0.0
	83	25.4	7.8	2.7	7.6	1.0	0.1	3.3	0.1	0.3
	84	33.5	6.5	6.6	6.3	0.7	0.0	3.5	0.1	2.4
VENEZ.	85	41.9	12.1	5.5	8.8	2.1	0.5	4.6	0.1	1.0
	86	54.7	13.6	8.1	7.8	2.2	1.0	4.3	0.3	0.9
	87	68.1	19.4	6.4	15.5	3.2	0.4	4.5	0.3	0.4
	83	20.6	3.7	3.4	3.0	3.5	1.1	0.1	0.0	1.4
	84	22.6	4.7	5.8	2.2	4.8	0.5	1.3	0.0	0.6
ARG.	85	31.4	6.8	7.0	6.0	3.4	1.7	1.0	0.0	1.1
	86	16.4	2.3	6.3	3.1	1.7	0.2	0.7	0.0	0.7
	87	38.3	3.0	8.6	4.7	1.5	4.6	1.6	0.0	1.9
	83	18.1	5.5	1.4	1.8	0.5	0.2	3.3	0.3	0.3
	84	19.7	9.6	1.6	1.1	0.1	0.2	2.3	0.3	0.2
COLOMBIA	85	11.4	5.4	0.8	0.4	1.3	0.2	1.1	0.9	0.2
	86	11.6	2.2	1.3	1.2	0.1	0.6	2.0	0.3	0.1
	87	19.9	4.7	2.8	3.1	0.3	1.2	2.7	0.3	0.6
	83	7.4	0.5	1.3	1.7	1.8	1.8	0.3	1.4	0.5
	84	2.8	0.8	0.4	0.3	0.0	0.0	0.1	0.1	0.1
PERU	85	3.4	0.5	0.4	0.5	0.0	0.0	0.1	0.1	0.1
	86	6.5	2.4	0.3	0.7	0.7	0.0	0.6	0.1	0.1
	87	5.1	1.7	1.4	1.3	0.3	0.0	0.7	1.4	1.4
	83	7.8	1.3	0.3	0.5	0.1	0.0	0.4	0.1	0.3
	84	4.4	0.5	0.0	0.8	0.0	0.7	1.0	0.1	0.1
ECUADOR	85	10.3	0.9	0.6	0.7	0.0	0.1	1.0	0.2	0.4
	86	8.5	1.0	1.3	0.9	0.0	0.1	0.8	0.0	0.2
	87	8.9	3.0	1.2	1.9	0.1	0.0	1.2	0.0	0.0
	83	321.1	78.3	47.6	27.0	28.5	5.6	15.6	2.7	3.8
	84	310.2	93.3	40.1	39.8	28.3	6.1	10.3	1.4	6.4
ALADI	85	290.7	99.7	52.8	23.9	40.1	10.7	16.5	1.9	5.4
	86	345.6	147.3	66.3	25.8	26.3	11.3	15.3	2.8	5.3
	87	410.7	128.7	86.0	46.0	35.9	17.0	16.0	14.8	7.3

SOURCE: Chudnovsky, 1990

TABLE 20

MAIN MACHINE TOOL SUPPLIER COUNTRIES TO ALADI - 1983-1987 - %

IMPORT./YEAR		U.S.A	FRG	ITALIA	JAPAN	SWITZ	SPAIN	ARG	BRAZIL
	83	23,2	11,8	3,3	5,4	0,0	4,4	0,1	0,4
	84	31,2	10.2	1,1	10,3	2,0	2,5	0,2	1,2
MEXICO	85	42,4	14,7	3,2	20,3	3,5	5,2	0,5	1,4
	86	64,8	13,5	3,9	0,8	1,7	3,6	0,2	0,5
	87	61,8	18,4	3,7	5,3	3,4	1,5	0,0	0,5
	83	28,3	27,0	9,9	21,0	4,3	0,6	0,0	0,0
	84	31,5	16,8	38,8	6,4	2,4	0,7	0,2	0,0
BRAZIL	85	26,7	41,5	5,2	7,7	7,4	0,8	0,6	0,0
	86	16,2	39,1	8,9	14,8	10,1	0,6	1,3	0,0
	87	15,6	34,1	11,1	11,3	4,8	2,1	9,5	0,0
	83	30,7	10,6	29,9	3,9	0,4	13,0	0,4	1,2
	84	19,4	19,7	18,8	2,1	0,1	10,4	0,2	7,1
VENEZ.	85	28,9	13,1	21,0	5,0	1,2	11,0	0,2	3,3
	86	24,9	14,7	14,3	4,0	1,8	7,7	0,3	1,6
	87	28,5	9,4	23,9	4,7	0,6	6,6	0,3	0,6
	83	18,0	16,5	14,6	17,0	5,3	0,5	0,0	6,8
	84	20,8	25,7	9,7	21,2	2,2	5,7	0,0	3,7
ARG.	85	21,7	22,3	19,1	10,8	5,4	3,2	0,0	3,5
	86	14,0	37,8	18,8	10,4	1,2	4,2	0,0	4,3
	87	6,0	22,5	12,4	3,9	12,0	4,2	0,0	5,0
	83	30,4	7,7	9,9	2,8	1,1	18,2	1,7	1,7
	84	48,7	8,1	5,6	0,4	1,0	11,7	1,0	1,0
COLOMBIA	85	47,4	7,0	3,5	11,4	1,8	9,6	7,7	1,4
	86	19,0	11,2	10,3	0,5	5,2	17,2	2,6	0,9
	87	23,6	14,1	10,6	1,5	6,0	13,6	1,5	3,0
	83	6,8	17,8	23,0	24,3	24,3	4,1	18,9	6,0
	84	28,6	14,3	10,7	1,4	0,1	3,6	3,6	2,5
PERU	85	14,7	11,8	14,7	1,1	0,7	2,9	2,0	1,9
	86	36,9	4,6	10,8	10,8	0,0	9,2	1,5	0,9
	87	13,6	17,3	14,8	3,7	0,0	8,6	17,3	1,9
	83	16,7	3,8	6,4	1,3	0,5	5,1	1,3	2,6
	84	11,4	0,3	16,3	0,0	15,9	22,7	2,2	3,3
ECUADOR	85	8,7	5,8	6,8	0,4	0,6	9,7	1,7	3,5
	86	11,3	15,3	10,4	0,4	1,2	9,4	0,9	1,8
	87	22,5	13,5	21,3	1,0	0,0	13,5	0,0	0,0
	83	24,4	14,8	8,4	8,9	1,7	4,9	0,8	1,2
	84	30,0	12,9	9,8	8,8	2,0	4,3	0,5	3,1
ALADI	85	34,3	18,2	8,3	13,8	3,7	5,7	0,7	1,9
	86	42,8	19,3	7,5	7,8	3,3	4,4	0,8	1,5
	87	31,3	20,9	11,3	6,3	4,1	3,9	3,6	1,6

SOURCE: Chudnovsky, 1990

Table 21

BRAZILIAN MACHINE TOOL PRODUCTION, EXPORTS AND IMPORTS
BY TYPE OF MACHINE - 1986-1988
in units and value (US$ millions)

A - VALUE

Machine Tools	1986 P	1986 M	1986 X	1987 P	1987 M	1987 X	1988 P	1988 M	1988 X
Metal-cutting	45.0	46.5	11.8	44.9	84.0	10.9	41.4	121.6	19.3
(%)	82	71	45	86	74	45	77	74	48
Deform-ation	10.2	18.5	14.5	7.4	29.7	13.6	12.2	42.2	20.7
(%)	18	29	55	14	26	55	23	26	52
Total	55.2	65.0	26.3	52.3	113.7	24.5	53.6	163.8	40.0
(%)	100	100	100	100	100	100	100	100	100

B - UNITS

Metal-cutting	23908	9452	6477	25920	2113	4344	30717	3734	4296
(%)	83	87	80	87	80	65	89	78	56
Deform-ation	4793	1381	1595	3951	535	2360	3737	1046	3372
(%)	17	13	20	13	20	35	11	22	44
Total	100	100	100	100	100	100	100	100	100

Source: ABIMAQ (1989)

Table 22

BRAZILIAN MACHINE TOOL TRADE COEFFICIENTS
BY TYPE OF MACHINE - 1986/1988
in % of value

Coefficients	Metal Cutting 1886	1987	1988	Deformation 1986	1987	1988	Total 1986	1987	1988
Imports/ Aparent Consumption	9.6	16.1	16.3	17.4	32.9	42.0	12.2	26.7	24.8
Exports/ Production	2.6	2.4	4.6	14.2	18.4	17.0	4.8	4.7	7.5

Source: calculations from Table 21

As indicated in Table 23, the average price of imported equipment tends to be significantly higher than average prices of locally-produced equipment (an exception to this occurred in 1986, when the exchange rate was frozen in Brazil). This would suggest, prima facie, that imports cover more complex models than those locally manufactured, yet this conjecture calls for additional research studies before it can be confirmed.

Table 23

AVERAGE VALUE OF MACHINES PRODUCED, EXPORTED AND IMPORTED IN BRAZIL - BY TYPE OF MACHINE - 1986/1988

in US$ 1,000/unit

Type of Machine	Total Production			Exported			Imported		
	1986	1987	1988	1986	1987	1988	1986	1987	1988
Metal-Cutting	18.82	17.32	13.48	1.82	2.51	4.39	4.92	39.75	32.57
Deformation	21.18	18.73	32.65	9.09	5,76	6.14	13.40	55.51	40.34
Total	19.23	17.51	15.56	3.26	3.65	5.15	6.00	42.94	34.27

Source: Calculations from Table 21

Unfortunately, the type of customs tariff classifications adopted in the various countries does not permit a distinction between NCMTs and other equipment, except with regard to Argentina and to Mexico. In the first country NCMTs account for 20% of imports (US$ 9 millions) in 1988, of which, 70% are lathes and 30% are milling machines. In Mexico the share of NCMTs is substantially higher - about one fourth of total imports of machine tools (Humbert, 1989). In 1988, NCMTs imports totalled US$ 41.5 millions, of which 61% were for machining centers, and 34% for lathes (ibid).

A second exception, if only a partial one, is Brazil, where we have been able to identify machining centers that answered for 4.3% of the country's total imports in 1987 (US$5,196 millions). As shown in Table 12, Section III, the number of NCMT units imported by Brazil, dropped from 300 units in 1980 to 30 units/year during the bleakest period in the crisis of the eighties (1982-83). Such imports partially recovered in the recent past, to 180 and 150 units/year in 1986 and 1987, respectively.

Finally, it should be noted that, in view of the local industry's greater development, imports of parts and components have played a far more important role in Brazil than in the remainder of the region. Whereas in Brazil they absorb 38% of the total machine tool imports, their participation in the remaining Latin American imports averages one fourth of the total figure (estimation based on Chudnovsky, 1990).

TABLE 24

MACHINE-TOOL TRADE BALANCE FOR ALADI COUNTRIES 1980-1987 (US$ MILLION)

COUNTRY	1980		1981		1982		1983		1984		1985		1986		1987		1988	
	EXPORT.	IMPORT.	EXPORT.	IMPORT.	EXPORT.	IMPORT.	EXPORT.	IMPORT.	EXPORT.	IMPORT.	EXPORT.	IMPORT.	EXPORT.	IMPORT.	EXPORT.	IMPORT.	EXPORT.	IMPORT.
COLOMBIA	4.0	33.3	3.5	35.2	1.9	27.1	1.2	20.0	0.4	21.8	0.5	12.9	0.5	14.1	n.a.	19.9	n.a.	n.a.
ECUADOR	-	15.5	-	14.5	0.5	12.3	-	10.1	0.2	5.3	-	n.a.	-	n.a.	n.a.	8.8	n.a.	n.a
PERU	0.9	16.1	0.2	19.8	0.1	21.0	-	9.0	0.1	4.4	-	3.6	-	7.9	n.a.	8.1	n.a.	n.a.
URUGUAI	-	-	-	-	-	-	-	-	-	0.6	-	0.7	-	-	-	-	-	-
VENEZUELA	-	-	-	-	-	88.7	0.4	35.0	-	44.0	-	54.3	-	-	n.a.	68.1	n.a.	n.a.
BOLIVIA	-	2.1	-	2.3	-	1.2	-	2.2	-	n.a.	-	n.a.	-	-	n.a.	1.5	n.a.	n.a.
ARGENTINA	28.0	94.1	17.1	69.6	9.0	39.2	3.3	20.5	3.0	22.5	3.7	31.3	4.7	16.4	15.9	38.3	32.6	44.6
BRAZIL (1)	71.5	17.5	73.9	123.6	20.8	85.2	24.1	44.2	20.2	39.9	28.0	40.4	26.3	65.1	24.4	113.6	40.0	163.7
MÉXICO (2)	n.a.	406.2	4.0	508.2	2.0	328.7	2.0	189.6	n.a.	178.2	3.0	148.1	1.0	177.2	n.a.	126.4	n.a.	n.a.
ALADI (2)	104.5	859.3	94.9	869.2	32.6	628	29.2	322.8	24.7	311.2	32.3	280.9	31.5	345.6	40.4	410.7	n.a.	n.a.

(1) DATA FROM ABIMAQ - SINDMAQ (1989)

(2) IMPORT VALUES FROM CHUDNOVSKY (1990), Exports from Humbert (1989)

SOURCE: UNIDO, PRODUCTS CLASSIFIED BY SITC, POSITIONS 736, REV.2.

As shown in Table 24, all Latin American countries show deficits in their trade balances as regards machine tools, and the import/export ratio has tended to increase in the last decade.

Regional exports originate chiefly in Brazil and Argentina. In the former case, after reaching about US$74 millions in 1981, exports dropped to less than one third of that amount by 1987 and experienced a partial recovery in 1988, when they went up to US$40 millions. That decline was strongly associated to the behavior of the Mexican market, which absorbed in 1980 approximately 60% of the exports made by Brazil and continues to be the latter's major external market. However, Chudnovsky (1990) points out that stamping machines, which accounted for a substantial part of the Brazilian exports to Mexico in 1987, do not appear in Mexican import statistics. Therefore, Brazilian participation in Mexican imports, as shown in Tables 19 and 20, is likely to be underestimated.

To judge from the average values of machines that are locally produced and subsequently exported (as shown in Table 23), Brazilian exports have consisted mainly of relatively cheap units as compared to the industry's average prices. This suggests that they are relatively simple models, a finding that is consistent with the weight assumed by Latin American markets in relation to those exports. It may, however, mean that low export prices are subsidized by high internal prices, an issue which requires further research.

Furthermore, it should be noted that more than half of the machine tool exports made by Brazil consist of forming machines, a sector in which technical advances have been less pronounced than in the sector of cutting machines, thus tending to confirm the suggestion above. We would like to stress that, although the Brazilian machine tool industry presents a very low export coefficient (roughly 8% of its production), the coefficient for the sector responsible for the production of forming machines attained international levels in 1988 -- 42% of the total production (see Table 22). We may also conjecture that the higher unit value of forming machine exports as compared to metal cutting machines indicates that exports of the former comprehend somewhat more complex models.

According to Chudnovsky (1990), an examination of the various different products shows that outstanding among forming machine tools are stamping machines, while parallel lathes are outstanding among cutting machines.

As already indicated, prices for parts and components in Brazil are substantially higher than those prevailing in the international market, especially with regard to parts that are used in the more complex machines. To these must be added the costs inherent in the need to offer intra-company training to skilled workers both at the intermediate and top levels, costs which, in other countries, are only partially absorbed by manufacturers.

In view of the great changes introduced in the technical basis of the machine tool industry at the international level, which tend to raise the minimum standards set up for research and development as well as increase the importance of static and dynamic economies of scale, Brazilian products are likely to meet with growing difficulties to enter more sophisticated markets than those found in Latin America, unless a major effort at rationalization is made in the sector, along with some heavy investments in both labor training and research and development procedures. This will require intensive governmental participation in close association with current manufacturers and their respective suppliers. A rise in the sector's import coefficient in order to increase the competitiveness of Brazilian exports is an important part of that policy, provided it can be articulated with measures designed to promote technological and industrial capability.

Although Argentinian exports have suffered a sharp decrease in the eighties (from US$28 millions in 1980 to US$4.7 millions in 1986), reflecting a combination of their domestic crisis and the Mexican collapse, the values attained early in the decade were recovered and surpassed in 1987, when they reached US$38 millions (see Table 24).

In Argentina, in contrast to Brazil, exports have gained considerable importance in the recent past, particularly where more complex machines are concerned. From accounting for 14% of the country's production in 1986, exports have thus come to represent two thirds of the latter in 1988. The major export products are CNC lathes, which alone answered for 30% of 1988 exports. In the latter year, 85% of the lathes manufactured in Argentina were exported (Chudnovsky, 1990. See also Table 14).

That export performance concerning relatively sophisticated products seems somewhat surprising at first. A study conducted in the recent past by Chudnovsky and Groisman (1987) showed that the prices of Argentinian NCMTs were substantially higher than those practiced by competitors from Japan, South Korea and Taiwan in the American market (about twice to three times as high as these). The economies of scale obtained by the latter countries were pointed out as the major determining factor in that price differential, even though in Argentina the engines and all electronic components for machine tools are imported, representing about one-fourth to one-third of production costs.

On the other hand, the same study indicated that simpler machines manufactured in Argentina were in a good position to meet price competition from their counterparts made in advanced countries, though they still had some difficulty to compete with products originating from Southeast Asia.

That apparent paradox finds its solution in the earlier described Integration Agreement between Brazil and Argentina. In fact, in 1988 Brazil absorbed almost three-fourths of the Argentinian machine tool exports and over 90% of their NC lathes. As analysed by Erber (1989) in further detail, Argentinian lathes are simpler and substantially

cheaper than Brazilian-made ones, regardless of the fact that they must be equipped with Brazilian NC cabinets.

As pointed out by Chudnovsky (1990), apart from NC lathes, Argentinian exports of machine tools are chiefly made of automatic and parallel lathes, milling machines, eccentric presses, and grinding machines. Except for the latter, the Brazilian market accounts for two-thirds to three-fourths of those exports from Argentina.

Other Latin American countries absorb the remainder of Argentinian exports, with Chile standing out as the second largest buying market for NC lathes (ibid).

The small exports made by other countries in the region (see table 24) seem to have sporadic character and, consonant to the development level of their respective industries, appear to consist mainly of very simple products.

The forgoing analysis of the evolution of machine tool imports in Latin American countries demonstrates the region's growing isolation as compared to international industry. Considering that the bulk of Latin American exports have an intra-regional character, that isolation tends to be maintained and to generate a vicious circle in the supply and demand of products which are increasingly lagging behind the international frontier.

The results of the commercial agreement between Brazil and Argentina, positive as they inequivocally are, cannot be mechanically extrapolated to the remainder of the region, inasmuch as no other country within it boasts a tradition in machine industry similar to Argentina's, which has enabled that country's machine tool industry to find a niche for its products within the Brazilian market and exploit it to the fullest. As already discussed earlier on in the present work, the Agreement itself must have its scope duly extended in order that it may eventually have significant effects on the restructuring of both countries' machine tool industry.

Notwithstanding the above, there does exist ample unexplored room for cooperation among various countries in the region. Given the relative size of the Brazilian machine tool industry and its greater dynamism, regardless of the current recessive context, the stand taken by Brazil as regards regional cooperation has a decisive character. In this sense, the Agreement's positive results and also its flaws may be illuminating in terms of the course to be followed.

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ABBREVIATIONS

AAFMHA - Asociación Argentina de Fabricantes de Maquinas Herramientas y Accessorios

ABIMAQ - Associação Brasileira da Industria de Máquinas e Equipamentos

BNDES - Banco Nacional de Desenvolvimento Econômico e Social

FEDEMETAL - Federación Colombiana de Industrias Metalurgicas

FINAME - Financiadora de Máquinas e Equipamentos

FINEP - Financiadora de Estudos e Projetos

NAFINSA - Nacional Financiera

SEI - Secretaria Especial de Informática

SENAI -Serviço Nacional de Aprendizado Industrial

SOBRACON - Sociedade Brasileira de Comando Numérico