The Brazilian Machine Tool Industry: Patterns of Technological Transfer and the Role of the Government

Flávio Rabelo Versiani and Vânia Lomônaco Bastos

STPI Background Paper No. 4

August 1982
The International Development Research Centre is a public corporation created by the Parliament of Canada in 1970 to support research designed to adapt science and technology to the needs of developing countries. The Centre's activity is concentrated in five sectors: agriculture, food and nutrition sciences; health sciences; information sciences; social sciences; and communications. IDRC is financed solely by the Government of Canada; its policies, however, are set by an international Board of Governors. The Centre's headquarters are in Ottawa, Canada. Regional offices are located in Africa, Asia, Latin America, and the Middle East.

IDRC Manuscript Reports

This series includes meeting documents, internal reports, and preliminary technical documents that may later form the basis of a formal publication. Manuscript Reports are given a small distribution to a highly specialized audience.
THE BRAZILIAN MACHINE-TOOL INDUSTRY:
PATTERNS OF TECHNOLOGICAL TRANSFER AND THE ROLE
OF THE GOVERNMENT

by

Flávio Rabelo Versiani and
Vânia Lomônaco Bastos

A study prepared by the Department of Economics of the Universidade de Brasília for FINEP - Financiadora de Estudos e Projetos. January 1976

STPI Background Paper No. 4
**CONTENTS**

1. Introduction and Summary ........................................... 1

2. Some Aspects of the Machine-Tool Market in Developing Countries........................................ 4


5. The Machine-Tool Industry: the Last Twenty Years and the Present Situation .................... 25

6. Concluding Remarks .................................................. 32

Appendix ............................................................................. 34

Bibliography ....................................................................... 35
1. **INTRODUCTION AND SUMMARY (**) 

Governmental technology policies in developing countries generally include among their stated objectives the creation of conditions favoring the adoption of modern, up-to-date productive processes in those economies. In addition to that, the **domestic** development of technology is frequently considered a more desirable means to acquire technical up-to-dateness than the mere importation of technology. Various reasons are presented for this preference. It is often argued, for instance, that the use of imported techniques leads to the adoption of productive methods ill-adapted to the relative factor endowment of developing countries; the development of indigenous technology could, conceivably, create conditions for a larger utilization of less automated productive equipment, increasing the labor-absorptive capacity of the manufacturing sector. On the balance of payments side, the development of domestic technical capability is seen as a way to ease the perennial tendency to a deficit in the service account of those countries. Also, from a more general viewpoint, the importation of technology is taken as one of the manifestations of the state of dependence of developing countries in relation to the central capitalist economies; domestic development of productive techniques would be, thus, one of the prerequisites for the elimination of this dependence.

In the Brazilian case the last development plans have consistently included as a goal the internal development of technical knowledge. The 1968 "Strategic Development Programme", for instance, has as stated objective "to capacitate the country to adapt and create its own technology, so as to reduce its dependence from external sources of know-how".**

Taking this capability to create technology internally as a measuring stick, the Brazilian machine tool sector is, at first sight,

* The authors acknowledge the helpful assistance of Renato Peixoto Dagnino, and are much indebted to Franco Vidossich for his generous cooperation. Emanuel Magalhães participated in the interviewing phase, collecting material for a parallel study, and made useful suggestions.

a success story. As it will be shown below, its beginnings can be located relatively early in the Brazilian industrialization process, as a sector dominated essentially by domestic capital, producing mainly domestically developed models. In 1970, when a major descriptive study of the sector was performed, this picture was still basically true.*

It must be made clear what 'domestically developed technology' means, in this context. We can have here anything ranging from a sheer copy of a model produced abroad to the internal development of a completely new conception, passing by various kinds of adaptations of foreign models. Of course the creation of something entirely new is evidence of a superior form of technological capability than mere copying. But it is important to consider model-copying as form of technology transfer basically different from the standard forms of importation of technology: the capacity to copy is closely related to the capacity to adapt (and to the capacity to diminish the degree of technological dependence); and, of course, copying is cheaper than buying a licence, and thus the foreign-exchange-saving element is there.

Taking this characteristic of the Brazilian machine tool industry as given, some interesting questions suggest themselves. Can we consider the technological domestic capability of the machine tool industry as being to any extent a result of deliberate governmental policies? In general, how have those policies affected the evolution of the industry? Also, given that the Brazilian government has been, in the last few years, involved in an effort to expand the domestic production of capital goods, what are the prospective effects of this effort upon the machine tool industry, as far as technology transfer is concerned?

This paper attempts to supply answers to those questions. It is based on secondary information from various sources concerning the Brazilian machine tool industry, and also on material collected in interviews conducted

* Instituto de Planejamento Econômico e Social, A indústria de máquinas-ferramenta no Brazil, by F. Vidossich et al., Série Estudos para o Planejamento, N°8, Brasília, IPEA, 1974.
in twenty firms of this manufacturing sector, in July-August 1975, in São Paulo and Rio Grande do Sul states.*

In brief, it is suggested here that: (a) The 'model' of technology transfer prevalent in the industry until recently (based, as it was said above, on domestically developed technology), was not importantly affected by technological governmental policies, but was brought about by peculiarities of the demand structure of the industry, coupled with factors associated with the general pattern of Brazilian industrialization. (b) The recent upsurge of growth in the machine-tool industry, starting around 1970, seems to have been marked by the predominance of a new 'model' of technology transfer, based mainly on the establishment of Brazilian branches of foreign firms. This new development also cannot be understood adequately without reference to the overall nature of recent Brazilian economic growth, and of the general orientation of governmental economic policy; however, it does not seem to have resulted from any specific set of deliberate technology policies. (c) The trend now seems to be in the direction of a decisive predominance of the new model.

The scheme of the paper is as follows. In the next section, some general points related to the demand and supply of machine tools in a country like Brazil are analysed. Next, a sketch of the early evolution of the Brazilian machine-tool industry is presented. The fourth section deals with governmental policies affecting the evolution of this industry in the last two decades, while the fifth section describes the main traits of the development of the industry and its present prospects. The concluding section puts together some general conclusions, and addresses itself briefly to the question of the discrepancy between governmental intentions and governmental technology policies.

* See the Appendix for a description of the criteria used to select this sample.
2. SOME ASPECTS OF THE MACHINE-TOOL MARKET IN DEVELOPING COUNTRIES

a) Demand

A machine tool can be defined as "a non-portable machine, operated by an external source of power, designed to work as a tool or to form the metal by cutting it, by impact by pressure of electrical processes, or by a combination of such processes."* Its importance as a capital good is clear from the fact that a very large proportion of transformation processes in manufacturing activities generally involve some kind of metal processing. Around one third of all investment in the so-called metalworking industries (Non Electrical Machinery, Transport Equipment, Electrical Equipment, and Metallurgy) corresponds to the purchase of machine tools.**

Machine tools can be divided, in general terms, into two classes: the standard, or multi-purpose types, and the special-purpose machines. The former are, as a rule, simpler in conception and can be applied to a wide scope of metalworking operations; an example is the standard lathe. Special-purpose machine tools are devised to perform more complex transformation processes, as those involving the application of several cutting or deforming operations to the same metal part, and are particularly adequate for production in large scale of a single type of output.

Very often it is possible to substitute standard machines for special-purpose ones: the same operation performed in the latter can be done by means of several passages in one or more types of standard machine. When costs are taken into consideration, however, a distinction between the main users of the two classes of machine tools can be defined. On the

** Ibid, pp. 9-10.
one hand, standard machines are used mainly in repair shops or small plants, where variety of operations predominates over repetitiveness. On the other hand, industries producing in series, especially in large scale, demand mainly special-purpose machines.

It is to be expected, therefore, that demand for standard-type machine tools should be relatively more important in the first stages of the industrialization process, while the development of a more complex industrial structure would favor the increased demand for special-purpose machines. For one thing, the relative importance of small, handicraft-type producers is clearly larger in less developed industrial economies: in addition to that, there are reasons to suppose that repair work is to be more common in those economies than in highly industrialized ones. This latter point deserves some elaboration.

The kind of repair and maintenance (R & M) work that utilizes machine tools has to do mainly with capital goods. It is reasonable to assume that demand for R & M will be directly related to the average age of the stock of those goods. As productive equipment grows old, the entrepreneur is faced with the alternative of keeping it in operation, incurring the costs of larger R & M expenditures, or of replacing it with new equipment — incurring the costs of this additional investment. If that new equipment embodies some kind of technological innovation which cannot be incorporated in the existing machinery, its adoption becomes, of course, more attractive.

If the equipment owner is a cost minimizer, he will opt for the least-cost alternative. Replacement is bound to be favored, under those circumstances, if investment plus labor costs associated with the adoption of the new equipment are smaller than the operating costs — including repair and maintenance — with the existing equipment.

Suppose that the planning horizon of the entrepreneur is one year, and that he is interested in deciding whether to keep his equipment for another year or to replace it now. The comparison between the yearly costs with each
alternative will inform his decision. Replacement will seem advantageous (supposing the old equipment has no scrap value) if:

\[ wL_n + rK_n < wL_o + rK_r \]

where:
- \( L_n \) = labor input per unit of output with the new equipment
- \( K_n \) = unit investment costs associated with the new equipment
- \( L_0 \) = unit labor costs with existing equipment
- \( K_r \) = investment costs associated with repair and maintenance of existing equipment (assuming, to simplify, that those costs are zero for new equipment)
- \( w \) = wage rate
- \( r \) = rate of amortization plus remuneration of capital (= "rental rate" of the equipment)

From the above inequality, we get:

\[ \frac{r}{w} (K_n - K_r) < L_0 - L_n \]

We may reasonably assume that \( K_n > K_r \), and also that \( L_0 > L_n \). This latter assumption may be taken to reflect both the fact that existing equipment requires R & M work, while new equipment does not, and the existence of technological progress, saving labor in newer models. Granted those assumptions, the second inequality tells us that the higher the price of labor relative to capital, the smaller the inducement to replace, and the higher the demand for R & M services and equipment. What this means is that even if there is no possibility of substitution between capital and labor in the productive process, once equipment has been installed - that is, if the ex-post production function is limitational - the capital-good owner can still adjust himself to variations in relative factor prices via his replacement decision: given that the purchase of new equipment is, so to speak, capital-intensive relative to the keeping in operation of existing machinery, cheaper investment costs will tend to favor earlier replacement and cheaper labor will be a late replacement.*

* For a more extended treatment of this point, see W.E.G. Salter, Productivity and Technical Change (2nd. edition; Cambridge: Cambridge University Press, 1966), ch. v.
The preceding arguments suggest the following points, related to our subject:

i) To the extent that the same models of productive equipment are used in developed and underdeveloped economies, it is to be expected that in the latter case, labor being relatively cheaper, replacement will take place later, and demand for R & M will be larger relative to the capital stock.

ii) In less developed economies, where frequently the supply of capital goods is largely dependent on imports, balance-of-payments difficulties may be expected to increase the average life of capital equipment, by increasing the costs of new investment. (The increase in the cost of R & M investment if it takes place in the same proportion will not be enough to offset that effect, as a glance at the inequality above will show.)

iii) We should, thus, expect a higher relative demand for the services of multi-purpose machine tools: in less-developed economies than in highly industrialized ones; and in 'bad' than in 'good' times, as far as capacity to import is concerned, in less-developed economies.

b) Technology Transfer

A few observations are worth making here concerning the acquisition of know-how for internal production of machine tools in a developing economy.

It is generally true that the simpler types of machine tools, which are relatively more demanded in the earlier stages of industrialization, are also simpler to build than the special machines used, for instance, in large-scale production. It is to be expected, then, that the first types of machine tool produced in an industrializing economy are multi-purpose machines.

The access to technical know-how to produce those simpler machines can also be made in a comparatively simple manner: the Brazilian experience suggests that sheer copying of imported machines, often performed by immigrants with limited technical training, will do.
However, the progressive sophistication of the structure of demand for machine tools which follows the industrialization process seems to make import substitution in the machine-tool industry progressively more difficult. For one thing, the increase in demand for special-purpose machines means less standardization, smaller production series, and often higher demand for skilled labor, in the production of machine tools. Also, machine tools devised for use in large-scale production are often automated to various degrees, which adds to the complexity of their design and production. It is also true that the technical specifications of machine-tool users tend to become more demanding when the industrial structure becomes more complex: a machine tool used in an automobile assembly line has to be more precise than one used to produce the frame for a hand cart, for instance.

Machine copying is not enough, now, as a form of acquisition of know-how for domestic production of machine tools; a new model of technology transfer has to be found.
3. THE BRAZILIAN MACHINE-TOOL INDUSTRY:

EARLY EVOLUTION, 1930-1955

It is rather difficult to fix the time period when production of machine tools started in Brazil. The ECLA study of 1962 * takes World War II as the starting period, and points to import difficulties at the time as the main inducing factor. F. Vidossich, on the other hand, mentions some production taking place in the thirties, but asserts that the number of producers was less than ten, and the technological level was low. ** Given the lack of statistical data for this period, it is not easy to confirm those points. What seems beyond doubt is the fact that some production took place in the thirties; but many firms may have gone out of business, so it is hard to establish the relative importance of domestic supply at that time. The date of foundation of the surviving producers at some later date can be a misleading guide, since many machine tool makers started in a different line of production.

Repair shops, on one side, and producers in the metalworking branch, on the other, were the two main previous activities of the first machine tool producers, according to the indications we have. Repair shops were a by-product of the first manifestations of industrialization in the country, since the last decades of last century. The factories themselves had frequently large maintenance and repair departments, which were often required to make or adapt replacement parts, due to import difficulties or insufficient stocks. It is known that many of those shops evolved, in the thirties, to equipment producers. One of the firms included in our sample, for instance, was founded in 1931 as a maintenance and repair shop, later entered the machine import business, and finally started to produce its own models.


In many instances, machine-tool making started to fulfill an eventual need of the producing firm itself, or of one of its clients. One of the firms in our sample, for instance, was established in 1937 by an Italian immigrant to produce movie projectors. As they needed a milling machine, larger than the models available in the market, they decided to produce one. They were soon requested by other firms to produce additional units, and were forced to open this line of production. After some years they specialized completely in milling machines.

Almost exactly similar is the story of the largest lathe producer in Brazil, now a big concern, with extensive export business. The founder, also an Italian immigrant, started in 1938 as a plow maker, and only produced the first lathe because he needed one.

The role of immigrants, as illustrated in the above examples, was no doubt predominant in the beginnings of the machine-tool industry.* Being familiar with the utilization or the construction of those machines, Italian, German and Spanish immigrants, among others, were an important source of technical knowledge in the period. Even today, firms established by immigrants are numerically important: the majority of Brazilian firms in our sample, for instance, had been founded by first-generation immigrants.

Three governmental policies are worth examining in connection with the early development of the Brazilian machine-tool industry: (a) the equipment import prohibition of the thirties; (b) the exchange policy of the post-war period; (c) the foreign capital policy up to 1955.

(a) A prohibition to import equipment for the industries considered to be in a state of 'overproduction', enacted by the government in 1931, was in all probability instrumental in bringing about the initial nucleus of the machine tool industry, in the thirties.** The prohibition, established for a period of three years, was later extended, so that it was in force up to 1937.

* About the role of immigrants in early Brazilian industrialization see, for instance, W. Dean, The Industrialization of São Paulo, 1880-1945, Austin, University of Texas Press, 1969, especially ch. 4.

** Decree no. 19.739, of March 7, 1931.
The immediate justification for this measure was the balance-of-
payments crisis brought about by the Depression, and the consequent need
to keep imports under control. However, the lobby of textile mill owners
was one of the main forces behind it: plagued by excess capacity for years,
they wanted now to take advantage of the rapid increase in demand that
was taking place, without being bothered by new entrants. According to
the prohibition decree, a governmental department was empowered to recog-
nize a state of overproduction in a given industry; promptly most important
sectors were considered in such a state (textiles, food, footwear, hats,
etc.), and machinery imports were drastically curtailed.*

The effects of the prohibition upon the domestic production of
machinery can be evaluated by the evolution of the textile equipment industry,
over the period. This incipient activity received a vigorous impulse from
the demand shift toward internal production: the number of firms regis-
tered in the state of São Paulo as producers of textile equipment jumped
from six, with 75 workers, in 1929, to fourteen, with 843 workers,
in 1937. And from 1930 and 1936 the largest producer of looms increased
its monthly output from 30 to 130.**

Even in the absence of comparable information about domestic machine-
tool production, we may be certain that this activity enjoyed a similarly
favorable period. The import prohibition brought about increased utilization
of existing capacity and delayed replacement in all industries to which it

* About the prohibition episode, see: S.J. Stein, The Brazilian Cotton
Manufacture, Cambridge, Mass, Harvard University Press, 1957, ch. 8; F.R.
Versiani, "Technical Change Equipment Replacement, and Labor Absorption:
the Case of the Brazilian Textile Industry", unpublished Ph.D. dissertation,
Vanderbilt University, 1971, ch. 4; Dean, The Industrialization, Op.cit.,
ch. 10.

applied, most notably the textile industry, which doubled its output from 1930 to 1937, with marginal increases in installed capacity.* This naturally caused an increased demand for repair and maintenance services, with positive effects on the demand for machine tools.

As mentioned above, and evidenced in our interviews, copying foreign models was - and to a large extent, still is - the standard means of designing a new model for domestic production. The imported machines are disassembled, and an effort is made to reproduce their parts, if possible using the same material; when necessary, simplifications or adaptations are performed. It is probable that, in the initial stages of development of the industry, the copying process would be sometimes crude, and the final product lacking in precision. However, the type of demand to be satisfied was such as to make mechanical exactness unnecessary, especially in the presence of obstacles to importation. Copying was, therefore, an effective way to absorb know-how from abroad.

World War II marked an extension of the period of import difficulties. There are indications, however, that lack of imported materials, especially steel, exercised an offsetting influence on the development of the domestic production of equipment.**

(b) After World War II, exchange regulations appear as the main policy instrument affecting the industrialization process.*** While the effect of the adopted policies favored the internal production of consumer goods, domestic equipment production was hampered by the preferential treatment given to imports in this category.

---

Immediately after the War, there were no obstacles to imports, even though the fixed exchange rate was rather overvalued. With the rapid exhaustion of the country's international reserves, the Government opted for a direct control of imports rather than a devaluation, partly with the purpose of avoiding inflationary pressures. Foreign exchange was allotted to importers according to criteria based on the essentiality of the goods to be imported. By and large, machinery and some inputs were attributed high priority, while luxuries and goods that could be produced internally were penalized. The system was, thus, doubly favorable to the internal production of difficult-to-import goods: protection from external competition was assured, and at the same time it was possible to import the necessary machinery at an overvalued exchange rate. By the same token, however, domestic production of machinery was discouraged. This effect was felt in the machine tool sector, and some firms were forced to abandon this line of production.* By 1949, 68.9 percent of the value of the internal supply of metalworking machinery corresponded to imports.**

The rapid growth of industrial output in the early fifties would, on the other hand, created a derived demand for machine tools, determining a renewed interest for local production.*** In 1955, total Brazilian output of machine tools was in the neighborhood of 4,500 units, and imports corresponded to only 34.7 percent, in number of units, of internal supply (and 53.9 percent, in weight).****

(c) It could be asked whether the predominantly national character of the machine-tool industry would have been affected by governmental policies that had the effect of repelling foreign capital. It turns out, however, that the policies adopted in this respect before 1955, even if they were not markedly attractive to the foreign investor, would not, by themselves, check

---

**** Ibid., pp. 36, 41.
the inflow of capital. The main manifestation of foreign capital policy, in the period, was represented by limitations to capital repatriation (20 percent a year) and to profit remittances (8 percent a year), which had been established in the 1930's, during the Vargas dictatorship. After the War, those limitations were repeatedly raised and then applied again, according to changes in the balance-of-payments situation. In general, periods of absence of restrictions prevailed, so that the relatively low level of foreign investment, in the period, "should be attributed more to external factors (post-war reconstruction period) ... than to the lack of an adequate 'climate'".*

As far as the machine-tool industry was concerned, we could add that the exchange policy tended, in any case, to direct investment to the more protected sectors, and the models of higher technological content, in which foreign producers would have a clear advantage, were being imported without restrictions.

To sum up, the early development of the machine-tool industry was marked by the production of domestically developed models (in a sense), with the predominance of nationally owned firms. Those characteristics, even though affected by various governmental measures, were not the result of deliberate policies.

---

4. GOVERNMENTAL POLICIES AND THE MACHINE-TOOL INDUSTRY, 1956-1975

In this section we intend to examine the main lines of economic policy in the period since 1956, as regards their influence on the development of the machine-tool sector.

The second half of the 1950's marks a new phase in the development of the Brazilian economy, to the extent that the acceleration of industrial growth was accompanied by deep changes in the structure of its output: industries like Transport Equipment, Electrical Equipment, Metallurgy, and Machinery had a very rapid growth. Also, governmental action in the economic field became more coordinated, at the same time as the goals of the government were made more explicit, with the elaboration of development plans.

In the first part of this section, a description is made of the main policy objectives, as stated in the government plans, which had some bearing on the machine tool industry. On a different level, the second part describes some effectively adopted policy measures - actions, instead of intentions - which directly or indirectly affected that sector.

It may be useful to take a previous look at Table 1, in which the growth rates of Domestic Product and of Industrial Output are shown. It is seen that the period since 1956 can be divided into three distinct subperiods, taking the years of 1961 and 1967 as dividing marks.* In 1956-1961 the average yearly increase of GDP was 7 percent, while real industrial output grew at 11.3 percent. This was a period of accelerated industrialization based on import substitution. In the years 1962-1967 there was a considerable fall in the growth rates, at the same time as

---

### TABLE I

**BRAZIL: GROWTH RATES OF GNP AND INDUSTRIAL OUTPUT - 1955/1974**

(YEARLY PERCENTAGE GROWTH)

<table>
<thead>
<tr>
<th>YEAR</th>
<th>GNP</th>
<th>INDUSTRIAL OUTPUT</th>
<th>YEAR</th>
<th>GNP</th>
<th>INDUSTRIAL OUTPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1955</td>
<td>6.8</td>
<td>10.9</td>
<td>1965</td>
<td>2.7</td>
<td>-4.6</td>
</tr>
<tr>
<td>1956</td>
<td>1.9</td>
<td>5.5</td>
<td>1966</td>
<td>5.1</td>
<td>12.4</td>
</tr>
<tr>
<td>1957</td>
<td>6.9</td>
<td>5.6</td>
<td>1967</td>
<td>4.8</td>
<td>1.7</td>
</tr>
<tr>
<td>1958</td>
<td>6.6</td>
<td>16.7</td>
<td>1968</td>
<td>9.3</td>
<td>16.9</td>
</tr>
<tr>
<td>1959</td>
<td>7.3</td>
<td>12.8</td>
<td>1969</td>
<td>9.0</td>
<td>10.4</td>
</tr>
<tr>
<td>1960</td>
<td>9.7</td>
<td>10.6</td>
<td>1970</td>
<td>9.5</td>
<td>10.4</td>
</tr>
<tr>
<td>1961</td>
<td>10.3</td>
<td>10.9</td>
<td>1971</td>
<td>11.3</td>
<td>10.1</td>
</tr>
<tr>
<td>1962</td>
<td>5.3</td>
<td>8.3</td>
<td>1972</td>
<td>10.4</td>
<td>13.0</td>
</tr>
<tr>
<td>1963</td>
<td>1.5</td>
<td>-0.3</td>
<td>1973</td>
<td>11.4</td>
<td>15.2</td>
</tr>
<tr>
<td>1964</td>
<td>2.0</td>
<td>5.0</td>
<td>1974</td>
<td>9.6</td>
<td>7.8</td>
</tr>
</tbody>
</table>

**Source:** Elaborated from data published by the Instituto de Planejamento Econômico e Social and Banco Central.
inflation rates accelerated vigorously. This period witnessed a change in political regime, with the rise of the military government in 1964. From 1968 onwards, there was a resumption of accelerated growth; this new phase was marked by dramatic expansion of exports, marked increase in the production of consumer durables and of capital goods, and increased concentration in the income distribution structure.

a) Governmental Intentions: The Development Plans *

Even though some experiments in investment planning had been tried after World War II, the 'Plano de Metas', elaborated for the period 1956-1960, can be considered the first attempt at global planning in Brazil. After this Plan, various other governmental plans and programmes of unequal scope and importance, were elaborated.

'Plano de Metas', 1956-1960
The 'Plano de Metas' established five priority areas of government action: basic industries, energy, transport, food production, and education. As far as industry was concerned, the general objective was the elimination of some bottlenecks in the country's industrial structure. Emphasis was put on the development of the following sectors: transport equipment, electric equipment, machinery, metallurgy of iron, aluminum and non-ferrous metals, cement, paper and cellulosics, and rubber products.

In so far as an important increase and diversification of industrial output was contemplated, new technology would be required. The Plan, however, did not deal explicitly with the problem; in fact, the inclusion of measures to facilitate the importation of equipment and the inflow of foreign capital could be taken to mean that those were the solutions envisaged for the absorption of technology.

'Plano Trienal', 1963-1965
The changes occurred in the economy caused the goals of the 'Plano Trienal' to be very diverse. Great emphasis was put in the control of inflation and in the recovery of high rates of growth. As far as technology was concerned, a change of attitude could be noted, since the need to develop productive techniques internally was mentioned. However, as the implementation of the plan was abandoned still in 1963, for political reasons, its formulations did not have any impact on concrete policies.

Inflation control and economic recovery - especially the former - were also the two main goals of PAEG. Going back to the general position of the 'Plano de Metas' in the technology question, PAEG made explicit the role of foreign capital as a conveyor of technical know-how. The need to attract foreign capital was a point made forcefully in the Plan.

As far as the domestic production of machinery was concerned, the creation of a special agency to finance Brazilian-made capital goods (FINAME) was mentioned in the plan. It was also expected that governmental investments in overhead capital and in the metallurgic and chemical industries would have a favorable effect on domestic production of equipment.

Even though the main goals of PED were still the decrease in inflationary rates and the increase in growth rates, the latter objective had now the greater emphasis. It was proposed that the recovery of economic growth should take place by means of an expansion of the internal market and the continuation of the import - substitution process. The domestic development of technical productive processes is mentioned here, for the first time, as an explicit goal. The strengthening of the internal market required larger absorption of labor in industry; to attain this goal the utilization of techniques more adapted to the factor endowment of the country would be necessary. Thus, the substitution of imported goods should be complemented by a substitution of imported technology, understood as the 'adaptation of imported technology and the gradual creation of an autonomous process of technological advance'.

All the following plans presented as a goal the development of autonomous technological capability, even though the relationship between that and the expansion of the internal market was abandoned. In fact, economic recovery followed a different path than that envisaged in PED.


Following the lines sketched in an interim programme for the years 1970-1971 ('Metas e Bases para a Ação do Governo'), the First National Development Plan reflects the optimism and euphoria of this period of spectacular performance of the growth indicators. The maintenance of high growth rates was the main goal; and for its attainment would require the strengthening of the competitive power of Brazilian enterprises in certain sectors, 'including some industries of high technological intensity'.* (36). This emphasized the need for domestic technological development. The implementation of the technology policy contained in PND-I was programmed in a separate document, the First Basic Plan of Technological and Scientific Development (PNBDCT).

'II Plano Nacional de Desenvolvimento', 1975-1979

This Plan was elaborated in a very different context than that of the previous ones. Recognizing the new difficulties, PND-II still keeps the goal of maintenance of high rates of growth; however, some cautions are added, and emphasis is put on the need to keep the balance of payments in equilibrium. The improvement in the distribution of income is also given new emphasis. As to technology, the development of domestic technological capability is kept as a basic goal.

The articulation (or lack of it) between the intentions stated in the plans and the policies actually put into effect will be examined in the next section.

b) The Implemented Policies and the Machine-Tool Industry

As suggested above, the correspondence between the policy objectives stated in the plans and the measures effectively adopted varied rather widely. On one extreme, we have perhaps the 'Plano de Metas' of 1956, whose objectives in fact dictated the policies of the following 5-year period. On the other, we have the 'Plano Trienal', which was entirely abandoned a few months after being prepared. Frequently, changes in the general conditions of the economy from the time of the elaboration of the plan to the time of its implementation made irrelevant some formulations of the plans.

* Ibid., quoting the text of PND - I.
The 'Plano de Metas' had, as it was mentioned above, short-run growth in some basic sectors as its main priority. To implement this objective and achieve the established goals, various policy instruments were mobilized, many of them affecting directly or indirectly the domestic machinery industry.

The establishment of the automotive industry was certainly the most important single factor. In order to fulfill the objectives of creating an automotive industry in Brazil, the government formed the 'Executive Group for the Automotive Industry' (GEIA). This was a task force in charge of the sector, having as members representatives of various governmental departments - an innovation which proved rather effective in circumventing bureaucratic obstacles, and was later extended to other industries. GEIA was empowered to offer substantial benefits to automobile makers wishing to establish branches in Brazil, especially in connection with the importation of equipment. Of course the domestic machinery industry was hardly prepared to supply the large amount of complex equipment demanded by the simultaneous installation of various automobile plants; in this sense, the granting of incentives for equipment importation did not represent an important loss to internal production. On the other hand, GEIA required from the automotive firms a plan of progressive shifting of part purchases to the domestic market. This caused very widespread backward effects; literally hundreds of firms, many of them small concerns, entered the part business, which had a very favorable impact on the machine-tool industry.

The granting of benefits for the importation of equipment was also adopted in relation to the other sectors included in the plan. The domestic producers of equipment, however, had an important protecting instrument in the so-called 'Law of Similars': if an importable good had a domestically produced 'similar' registered in the appropriate government department, its importation would be made prohibitively expensive, in most cases.

It should be mentioned that very favorable conditions for the inflow of foreign capital existed in the period. Foreign investors were, for instance,
allowed to import machinery without exchange cover, which in fact put them in an advantageous position vis-a-vis the domestic investor.*

In the period 1961-1964, even though there was a new economic plan, no important policy measure can be mentioned, since the plan was not, in fact, put into effect. An exception would be a new foreign capital law, fixing restrictions on capital repatriations and remittances, and on payments referring to technology transfer.** In fact, however, the law was not regulated until January 1964, only to be modified a few months later, after the rise of the military government. The effect of this temporary change of climate for foreign capital was unimportant.***

In the period 1964-1967, the struggle against inflation dominated the conduct of economic policy; the measures adopted to further economic recovery were timid, on the whole, and did not achieve much success. With the recession, and the reduction in private investment, one should expect a sharp reduction in demand for the equipment industries. However, a very important offsetting effect was provided by the investment programs of the government in sectors in which it has important participation. This is shown in Table 2, which gives data for gross capital formation in the four industries in which the demand for machine tools is concentrated. It is seen that the fall in investment in transport equipment and in machinery - sectors dominated by private enterprise - is partly compensated by the significant increase in metallurgy, which basically reflects the program of governmental investment in the steel industry.

Economic recovery after 1967, and the maintenance of dramatically high growth rates in the succeeding years, would of course cause an increased demand for productive equipment. It is a matter of debate to what extent the boom was brought about, or importantly affected, by governmental policies; in any case, some characteristics of the accelerated growth, as well as some related policy decisions, clearly influenced the way that demand was satisfied.

* Pignaton, Op. cit., p. 18
** Law No. 4131, of Sept. 27, 1962.
TABLE II

BRAZIL: ESTIMATES OF GROSS CAPITAL FORMATION IN FOUR INDUSTRIES, 1959 - 1969

(Millions of 1969 cruzeiros)

<table>
<thead>
<tr>
<th>YEAR</th>
<th>METALLURGY</th>
<th>MACHINERY</th>
<th>ELECTRIC EQUIPMENT</th>
<th>TRANSPORT EQUIPMENT</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1959</td>
<td>337</td>
<td>137</td>
<td>131</td>
<td>556</td>
<td>1161</td>
</tr>
<tr>
<td>1962</td>
<td>549</td>
<td>156</td>
<td>118</td>
<td>311</td>
<td>1134</td>
</tr>
<tr>
<td>1963</td>
<td>565</td>
<td>118</td>
<td>97</td>
<td>192</td>
<td>979</td>
</tr>
<tr>
<td>1964</td>
<td>527</td>
<td>89</td>
<td>110</td>
<td>187</td>
<td>913</td>
</tr>
<tr>
<td>1965</td>
<td>654</td>
<td>93</td>
<td>83</td>
<td>190</td>
<td>1020</td>
</tr>
<tr>
<td>1966</td>
<td>514</td>
<td>98</td>
<td>158</td>
<td>297</td>
<td>1067</td>
</tr>
<tr>
<td>1967</td>
<td>460</td>
<td>97</td>
<td>144</td>
<td>358</td>
<td>1059</td>
</tr>
<tr>
<td>1968</td>
<td>362</td>
<td>135</td>
<td>153</td>
<td>447</td>
<td>1097</td>
</tr>
<tr>
<td>1969</td>
<td>516</td>
<td>193</td>
<td>183</td>
<td>458</td>
<td>1350</td>
</tr>
</tbody>
</table>

To begin with, it is relevant to note that, contrary to the formulations of the 1968 plan (PED), the recovery was not importantly based on the development of a mass market for wage goods, but had as its main dynamic element the demand for consumer durables, especially up to 1970.* The significance of this fact for the domestic equipment industry is that it made more difficult the implementation of another of the PED objectives: the development of domestic technology. For the very nature of the production of consumer durables, involving much product diversification and the constant introduction of new models, makes it much less amenable to independent technological development in a country like Brazil, especially considering that demand patterns for those goods are largely imitated from highly industrialized societies.

The government, in fact, made no important attempt to implement the objective of internal development, as far as the domestic capital goods industry was concerned. On the other hand, exemptions for the importation of industrial equipment were generalized. Following the GEIA scheme, Executive Groups for various industries were created in the sixties, and were consolidated in 1969 under the Council for Industrial Development. The Council, which had the task of examining requests for equipment importation, with the purpose of granting the exemption of tariffs and other taxes, in fact approved the requests wholesale.** This illustrates the fact that growth of product had absolute priority over technological autonomy.

The policy of easy imports was made possible not only by the very rapid expansion in exports, from 1968 on (an average yearly growth of about 30 percent), but also by the large inflow of loan capital from abroad, especially in the seventies. Contrary to the period 1955-1961, when high growth rates went together with a tight balance-of-payments situation, we had now rapid growth and high capacity to import. Paradoxically, the former situation may more easily lead to favorable policies towards the domestic capital good industry than the latter one.

** Ibid., p. 14.
Another decision related to imports which seems to have had an important effect on the machine-tool industry was the possibility of importation of complementary parts, with full or partial exemption of tariffs. A producer could, by act of the Council for Industrial Development, be allowed to include imported components in his output, having the same benefits granted to the importation of productive equipment. This measure was enacted in 1970, and regulated in 1971-1972.

After 1970, there are indications that the demand for capital goods showed a marked increase. The growth in industrial output in the period 1967-70 seems to have been largely based on existing unused capacity; it was not until the beginning of the 1970s that the maintenance of growth required important new investments, as a reflection of which the production of capital goods became the leading sector in terms of growth rates.* For the domestic machine-tool industry, which attained in 1971 levels of production never reached before, this would mean the beginning of a new period of growth.** In the next section, we will examine how the industry reacted to this stimulus, in terms of technological development.

We should mention, finally, that in the second half of 1975 the worsening of the balance-of-payments situation forced the government to adopt drastic restrictions to imports, and, on the other hand, to embark on a vigorous program of incentives to the domestic capital-good industry. It is, of course, too early to assess the impact of those measures upon the machine-tool industry.

---

* Ibid., p. 117
** The output of the Brazilian machine-tool industry increased from an average of 14,675 tons in 1967-70, to 22,424 tons in 1971. See the following section.
5. THE MACHINE-TOOL INDUSTRY: THE LAST TWENTY
YEARS AND THE PRESENT SITUATION

a) Stages of growth since 1956

Three distinct periods can be noted in the evolution of the machine-tool industry since 1956. The first (1956-1961) was marked by significant growth in output; in the second (1962-1970) output was relatively stable; and in the third (after 1971) output grows again, but in a context different from the first period (see Table 3).

It is to be noticed that those periods do not correspond well to those in which the development of the economy is naturally divided. In part this can be attributed to the specific characteristics of the demand for machine-tools. As mentioned before, the part of demand coming from repair and maintenance shops may be stable or even increase in a period of decrease in the level of activity; also, the increase in demand for machine tools in the expansion phase will depend on the existence of spare capacity.

1st period (1956-1961)

In this period, both imports and domestic production increased (Table 3). Those years witnessed great expansion of the sectors which are heavy users of machine-tools: this is indicated by the fact the participation of metallurgy, machinery, transport equipment and electric equipment on total industrial value added increased from 15 percent, in the 1949 Census, to 27 percent, in 1959.*

Increasing its output in response to the increased demand, the domestic machine-tool industry did not, by and large, change the technical content of its products. This is indicated by the fact that the average weight of domestically produced machines did not alter significantly over the period.** The expansion was, thus, more quantitative than qualitative.

* Based on data from A. Fishlow, "Origens e consequências da substituição de importações no Brasil", Estudos Econômicos II, n° 6, 1972.
** Cf. Instituto de Pesquisa Econômica e Social, Op. cit., p. 22. The average weight is commonly used as an indicator of the technological level.
<table>
<thead>
<tr>
<th>YEAR</th>
<th>DOMESTIC OUTPUT</th>
<th>IMPORTS</th>
<th>EXPORTS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>UNITS</td>
<td>TONS</td>
<td>UNITS</td>
</tr>
<tr>
<td>1955</td>
<td>4,478</td>
<td>5,085.6</td>
<td>2,378</td>
</tr>
<tr>
<td>1956</td>
<td>7,209</td>
<td>7,231.1</td>
<td>2,461</td>
</tr>
<tr>
<td>1957</td>
<td>6,626</td>
<td>6,598.8</td>
<td>4,350</td>
</tr>
<tr>
<td>1958</td>
<td>8,567</td>
<td>8,398.7</td>
<td>6,195</td>
</tr>
<tr>
<td>1959</td>
<td>8,812</td>
<td>9,006.8</td>
<td>10,954</td>
</tr>
<tr>
<td>1960</td>
<td>11,245</td>
<td>10,856.2</td>
<td>7,410</td>
</tr>
<tr>
<td>1961</td>
<td>15,517</td>
<td>13,249.9</td>
<td>5,604</td>
</tr>
<tr>
<td>1962</td>
<td>14,338</td>
<td>13,885.0</td>
<td>4,613</td>
</tr>
<tr>
<td>1963</td>
<td>13,302</td>
<td>13,296.4</td>
<td>2,573</td>
</tr>
<tr>
<td>1964</td>
<td>13,872</td>
<td>13,040.5</td>
<td>1,299</td>
</tr>
<tr>
<td>1965</td>
<td>11,651</td>
<td>11,835.9</td>
<td>1,294</td>
</tr>
<tr>
<td>1966</td>
<td>13,689</td>
<td>15,959.7</td>
<td>1,680</td>
</tr>
<tr>
<td>1967</td>
<td>12,107</td>
<td>13,102.1</td>
<td>2,014</td>
</tr>
<tr>
<td>1968</td>
<td>15,167</td>
<td>15,218.0</td>
<td>3,148</td>
</tr>
<tr>
<td>1969</td>
<td>13,878</td>
<td>15,010.2</td>
<td>3,048</td>
</tr>
<tr>
<td>1970</td>
<td>15,312</td>
<td>15,369.7</td>
<td>3,071</td>
</tr>
<tr>
<td>1971</td>
<td>17,289</td>
<td>22,424.3</td>
<td>4,058</td>
</tr>
</tbody>
</table>

This fact may help to explain why there was no important trend towards the entry of foreign firms in the sector, as it was mentioned above. The opening of a branch abroad is commonly motivated by the fear of losing a market: firms tend to emigrate to a certain country if they can no longer export to it. As the Brazilian firms kept producing only machines of low technological level, they did not compete with the imported production; on the other hand, the importation of more sophisticated machines was receiving incentives from the government. Foreign producers did not have anything to fear.

2nd period (1962-1970)

The recession was felt by the domestic machine-tool industry not as a decrease in demand, but as an interruption of the growth trend. As mentioned in the preceding section, the rise in investment expenditure in the metallurgical industry probably was at least in part responsible for this fact; we should also point to the demand from repair and maintenance shops. On the other hand, the fact that imports fell markedly between 1962 and 1965 is noticeable, showing that the demand for technologically advanced products did decrease.

Exports had an important role in internal demand, as seen in the Table. In 1962 exports were only 0.2 percent of domestic output; in 1970, this percentage was 26.0 percent.

3rd period (1971-1975)

In this period we have data for domestic output only in 1971, showing a relevant rise in production, as well as in the average weight of machines produced. Imports rose dramatically witnessing the increase in demand for more complex machines. The value of imports grows from US$59.6 million in 1971, to US$197.0 million in 1974, an increase of 130 percent in four years.* It is clear that the structure of demand for machine tools has changed.

* Ibid.
A new phenomenon in the development of the industry, observed in this period, is the entry of foreign firms, which is no doubt associated with the changes in demand structure just noted. In the July 1975 list of members of the São Paulo Association of Machine-Tool Makers, only nine firms controlled by foreigners could be pointed (out of a total of 96). Out of those nine, not less than five had been installed after 1968. In addition, it is known that various foreign groups are presently establishing plants in Brazil, either in association with Brazilian producers or not. There seems to be, in fact, something of a rush for association or purchase of Brazilian firms, on the part of foreign producers: practically all the Brazilian businessmen interviewed by us had been contacted with this purpose. The industry is, no doubt, entering a new phase: it is easy to predict that its property structure will show a marked change in the next few years.

b) The voice of businessmen in the sector

In this section we will examine more closely some of the answers received in our interviews with executives of the machine-tool industry.

The interviews actually were more wide-scope than the following set of points might suggest, since they had also the purpose of getting the researchers acquainted with relevant aspects of the industry.

Entry of foreign firms - Most Brazilian businessmen were apprehensive with the increase in the number of foreign firms in the sector. Even though the new producers presently do not have, in general, a line of production competitive with national firms, it is thought that, in case of a reduction of demand in their traditional products, they will shift to simpler, multi-purpose machines, whose demand tends to fluctuate less. In this case the foreign firms might easily, it is thought, throw the Brazilian producers out of the market.

The prediction of a shift in production by the foreign firms is certainly correct: it is generally technically possible, and it is the logical way out, in case of market difficulties. One of the foreign firm managers interviewed by us actually confirmed his intention of acting in this way.
About the reasons for the present inflow of foreign capital into the sector, it is thought that, besides factors such as good market prospects and cheap labor, some policy measures were also instrumental in attracting the foreign firms. The possibility of importation of complementary parts with duty exemption was apparently important in this respect, as were the export incentives.

Big purchasers of machine tools which are branches of foreign firms seem to play a significant role in prompting their suppliers abroad to open a Brazilian affiliate. Thus, the manager of a German subsidiary mentioned that his firm had come to Brazil through the recommendations of Volkswagen, for which they were projecting a new assembly line. Also, the establishment of the Fiat plant is now bringing in its wake some Italian machine-tool makers.

As far as Italian firms are concerned an 'expulsion' factor is generally mentioned: the fear of the rise to power of the Communist Party in Italy. If present electoral trends continue in that country, a rush of Italian firms to open Brazilian subsidiaries is predicted.

Another factor working in the same direction, in Germany, seems to be the increase in the value of the mark vis-a-vis the dollar. The consequent loss of competitive position of German exports induces producers in that country to open branches in the dollar area.

Technology transfer - Asked about their possibilities of developing the new models required by the market, the Brazilian producers generally insisted that they would be able, having enough time and resources at their disposal, to design and construct the machines. Copying would be still, even for the development of more sophisticated machines, an effective method of technology transfer. Licensing would not, in the view of some businessmen be a very appropriate means, since the foreign producers are in general reluctant to sell blueprints for their newest models; on the other hand, it would be easy to circumvent patent problems, when they exist, by means of a 'mixing' of various imported machines. The bottlenecks would be, then: the necessity
to start producing new models quickly, because of the competition ('The market cannot wait', said one of the interviewees); the scarcity of sources of capital to finance the development and testing of prototypes; and the scarcity of technically trained labor.

In the same vein, some Brazilian businessmen who had sold or were contemplating the selling of part of their business to a foreign firm (which in general insists in assuming control) maintained that, as one of them put it, their problem 'was not technology, but capital'.

Technological development - In accordance with their answers about technology transfer, when asked about what the government could do to foster the domestic development of technical processes the interviewees mentioned: a) various financing schemes for the development of new models: non-returnable grants; loans at zero interest rate; purchase of prototypes by the government; deduction from taxable revenue of a multiple of the expenses in research and development; etc; b) financing schemes for training of skilled workers and technical staff, especially abroad; c) importation of selected modern machines, for copying; d) improvement of technical education in general; e) creation or improvement of technological research institutions.

Incentives to the importation of equipment - The granting of benefits for the importation of equipment has been one of the main policy instruments to foster investment in certain industrial sectors. As we saw above, in general those benefits are only granted if the machine to be imported is not produced locally. The existence of a national 'similar' (which, according to the present procedures, is judged by the industry associations themselves) should in principle preclude tariff-exempt imports. Good application of the 'law of similars' is, thus, of crucial importance for domestic machine makers.

Asked about how well the machine-tool industry was protected by this mechanism, the majority of our respondents was pessimistic. In fact, 12 out of 20 answers expressed misgivings about it. The main problem seems to be the possibility of proving similarity in practice. According to law, to be considered similar to the imported product the domestic equipment has to
have: the same quality and technical specifications; a price not higher than that of the imported product, including tariffs and taxes; normal time of delivery. Apparently there are many ways to circumvent those rules. The importer may, for instance, place his order abroad and only request the import license some months later, so that no domestic producer can match the delivery time. Or he can make some exaggerated technical specifications, which he knows can be satisfied by the foreign producer, but not by the domestic one, at a small additional cost.

On the other hand, complaints are also made with relation to the fact that tariffs are too low, so that foreign machines similar to domestically produced ones are imported in large scale, all duties being paid. The solution, according to the respondents, would be the downright prohibition of the importation of goods with a domestically produced similar.

The worsening in the balance-of-payments situation, from 1974 on, has caused the government to adopt a less permissive attitude towards equipment imports, by simply delaying the exemption requests. Many answers expressed indirectly this fact, when they mentioned the 'more correct' position of the authorities, in the last months.
6. CONCLUDING REMARKS

As the preceding pages attempted to show, the Brazilian machine-tool industry is presently going through a transition stage. The entry of foreign subsidiaries, initiated in the last few years, will probably alter substantially the property structure of the industry. This fact marks, on the other hand, the adoption of a new 'model' of technological development. While up to now the prevalent mode of absorption and development of technology was internal to the domestic plant (via copying of models, or autonomous research and development, or a mixture of those), under the new model research and development will be typically restricted to the home company, and the absorption of new methods will be made by the simple importation of blueprints. It is highly probable that the recent measures adopted by the government, with a view to further internal production of capital goods, will have the effect of accelerating those transformations.

Judging by the formulations of the last governmental plans, the new technological development 'model' would be contrary to the objectives and policies of the government in the technology field. We would have, then, a case of conflicting goals. Taking a broader view, however, we see that the basic objective of government in the last decade has been the achievement and maintenance of high rates of GNP growth; in a sense, all other goals are subordinated. To the extent that the machine-tool sector did not create bottlenecks to growth, its performance agreed with the main objective of governmental policy.

The adoption of a different 'model' of technological development in the industry would require, in fact, a very diverse context. As it was said above, the direction taken by the growth of the economy during the post-1967 boom was probably the most important factor in precipitating the changes in the sector. It is not clear, however, whether a period of sustained growth based not on consumer durables, but on the development of a mass market for wage goods, could lead automatically to a very different model of technology development. As we saw in the first section, the more
technologically advanced machine tools are characteristically in demand in highly industrialized economies; the product-mix is not the crucial factor, in the long run.

In case the presently evolving model is considered unacceptable, only positive governmental action - probably of the kind envisaged by the producers themselves - seems to be the alternative.
APPENDIX

In the preparation of this study, a series of interviews was performed in twenty firms of the machine-tool industry. For the selection of this sample, we used the list of members of the 'Sindicato da Indústria de Máquinas do Estado de São Paulo', to which practically all industries in the sector are affiliated, complemented with various information about the industry furnished by Dr. F. Vidossich.

We sought to include in the sample firms having different characteristics as to: value of total output, value of output in the machine-tool department, size of labor force, types of machine-tools produced, cutting and forming machines, technological level of the product, foundation date, property status ('national' or 'foreign').

Since about 90 percent of the machine-tool industry is concentrated in the states of São Paulo and Rio Grande do Sul, we limited our sample to those states.

A questionnaire was prepared and presented to the respondents, who were either members of the board of directors or general managers, with two exceptions. Both closed and open questions were included, on the following items: general characteristics of the firm; forms of technological development (internal development or external purchase of technology); governmental technology policies; general considerations on the state of the industry.
BIBLIOGRAPHY


Fishlow, A. "Origens e consequências da substituição de importações no Brasil". Estudos Econômicos, II, n° 6, 1972.


