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The Development of the 'Electronics Complex' and Government Policies in Brazil

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Summary. — This paper reports some of the results of research conducted at the Instituto de Economia Industrial of the Federal University of Rio de Janeiro on the pattern of development of two industries of the 'electronics complex' — electronic data processing equipment (EDPE) and electronic semiconductor components (SCC). The industries were selected because of their technological and economic importance and for their potential inter-relatedness, as well as for policy-related reasons.

The research focused on the analysis of the international characteristics of the two industries (based mainly on secondary sources) and an empirical investigation of their pattern of competition in Brazil. Following a brief characterization of the 'electronics complex,' the next section of this paper describes the evolution of imports, local production and exports and the pattern of competition in the Brazilian market. The third section analyzes in more detail the inter-relations between consumers, international firms, local producers and Government policies, focusing mainly on the EDPE industry 'infant-industry' experience. The last section focuses on the intended policy for the SCC industry, exploring the implications of industrial interdependence and drawing from the experience of the EDPE industry. The article concludes by presenting some requisite characteristics of policy for fostering an 'electronics complex', which may be useful not only for Brazil, but for other LDCs as well.

1. INTRODUCTION

The importance of the electronics industries is now so well established that the general argument needs little elaboration. Given this importance, one of the main challenges faced by less-developed countries (LDCs), especially those that have advanced further in their process of industrialization, such as Brazil, Argentina, Mexico, South Korea and India, is to set up their own electronics industries. This task is conditioned by some characteristics of the electronics industries briefly described below.

One of the most important characteristics of the electronics industries is their interdependence. Although electronic products are consumed in many different markets, they have a common technical basis, founded upon the common use of specific technical and scientific knowledge, parts and components (notably electronic semiconductors) and processes of production. Such unity generates strong inter-industrial linkages, in terms of current (input–output type) supply relationships, as well as in terms of investment (in technology and productive capacity) and demand (for new and substitution products). Such linkages contain many feed-back loops and their effectiveness and strength tend to increase over time. Thus, the electronics industries form an '*industrial complex*', which can be seen as a *system of industries* that exhibit a synergistic interdependence where the rhythm of movement of each of its parts is different.[1]

The patterns of competition and of development in each of the electronic industries and in the electronics complex as a whole are marked by the multi-dimensionality of electronic products. Users of such products face different

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combinations of price, performance, durability and reliability, all of which tend to change quickly over time. Technical progress via product and process change (e.g., miniaturization and automation) plays a major role in stimulating the expansion of the electronics complex. These factors, plus static and dynamic economies of scale, have led to unit price reductions at the same time that the range of functions is increased. As a consequence, competition in such markets is characterized by product differentiation and by price competition. Because of the multi-dimensionality of the products, firms producing them can combine their resources in different ways so that the pattern of competition in the industry is multi-dimensional, too. Nonetheless, such resources have a minimum 'threshold', which varies according to products. Although the interdependence of the electronics industries tends to generate externalities and synergic effects, there are indications that the threshold of resources is rising.

This pattern of competition and development is further characterized by the roles played by government and multinational companies (MNCs). In the countries where the electronics complex developed, state intervention played a crucial role, particularly in stimulating the birth and growth of the industries which constitute the dynamic core of the complex, such as electronic data processing equipment and electronic components. This was done through the provision of technical resources and funds for research and development; protection of productive facilities against foreign competition; State procurement and other means.[2]

At the same time, the electronics complex is characterized by the strong presence of multinational companies, coexisting with small firms, which normally use their innovative capability as their main competitive asset. The different degrees of internationalization of the activities of such companies reflect the characteristics of electronic products and their markets. Thus, the activities related to sales and supporting services are the most internationalized, while those related to R&D are concentrated in the parent houses' countries. Profiting from the fact that they are assembling industries, MNCs have spread their industrial operations worldwide, but they tend to concentrate the activities that are more intensive in capital and technology in the more advanced countries.

This paper reports some of the results of the research conducted at the Instituto de Economia Industrial of the Federal University of Rio de Janeiro on the pattern of development of two industries of the electronics complex — electronic data processing equipment (EDPE) and electronic semiconductor components (SCC). The industries were selected because of their technological and economic importance and for their potential inter-relatedness, as well as for policy-related reasons. Since the early 1970s the Brazilian Government has followed a policy of fostering the development of EDPE activities. This culminated in 1977 with the decision to reserve for Brazilian-owned firms the Brazilian market for minicomputer and microcomputer systems. As a result of this decision, a locally owned industry has developed. At the time of the research, a policy for the SCC was being elaborated which shared some of the characteristics of the EDPE policy, but which also raised new problems related to the interdependence of the electronics industries.

The research focused on the analysis of the international characteristics of the two industries (based mainly on secondary sources) and an empirical investigation of their pattern of competition in Brazil. The latter, carried out in 1982, was based on interviews with enterprises covering about 90% of the output value of each industry. The reports of the research, including a fuller description of the analytical framework outlined above, are available on request.[3] The research on the EDPE industry was conducted by Paulo B. Tigre and Clelia V. Piragibe and the study of SCC by Glory Macknight, under the direction of the author.

The following section of this paper describes the evolution of imports, local production and exports and the pattern of competition in the Brazilian market. The third section analyzes in more detail the inter-relations between consumers, international firms, local producers and Government policies, focusing mainly on the EDPE industry 'infant-industry' experience. The last section focuses on the intended policy for the SCC industry, exploring the implications of industrial interdependence and drawing from the experience of the EDPE industry. It concludes presenting some requisite characteristics of a policy for fostering an electronics complex. This may be useful not only for Brazil, but for other LDCs as well.

2. THE BRAZILIAN MARKET — IMPORTS, LOCAL PRODUCTION AND EXPORTS

(a) *Local production and imports — the integration of the 'electronics complex'*

Production of EDPE and SCC in Brazil started

in the early 1960s, as a diversification of the activities of subsidiaries of multinational firms already operating in the country.[4] Unlike other LDCs, where the production of electronic goods was export-oriented, in Brazil their production was primarily for the internal market,[5] consisting mainly of the assembly of imported parts. Only recently have exports become important, for some of those firms, as we shall see below.

Although the Brazilian market is small when compared to those of the developed countries, it is one of the of the largest of the LDCs and it is not neglible in international terms. Thus, in 1981, although the Brazilian EDPE market was only 3% of the US market (10% of the Japanese), it was one of the ten largest national markets in the world. The Brazilian installed base of computers represented more than 50% of the Latin American total and about 2% of the world total. Similarly, in SCC the Brazilian market represented 2% of the US market but for some products, such as discrete components, it was equivalent to 6.5% of the latter market, in the same year.[6]

Nonetheless, local production was relatively limited for about a decade, so that by the mid-1970s the local market was supplied mainly by imports, which accounted for about 80% and 60% of the Brazilian market of EDPE and SCC, respectively.[7]

In the recent past, the two industries have followed different paths in terms of their reliance on imports. This is shown in Table 1, where imports of SCC rise from 43% to 51% of local consumption between 1978 and 1981. In EDPE, although 46% of the value of the installed base in 1982 still consists of imported systems, the locally produced systems, especially small- and medium-size units,[8] are rapidly increasing their share (see Table 2). In both sectors, imports tend to be concentrated in the more complex products. In EDPE, they are now mainly large, mainframe computer systems, while in SCC, imports of more complex integrated circuits have increased their share relative to discrete components between 1978 and 1981 (see Table 3).

At the same time, imports of parts and components soared. Intermediate imports play a major role in SCC production in Brazil since the local producers (of which all but one are subsidiaries of MNCs) import the products semi-finished. GEICOM's[9] data for the period 1977–81 show that input imports represented 44% of the value of production of SCC.

In the EDPE industry, imports of parts and components increased almost twenty times between 1973 and 1981. In the latter year, they represented about 20% of the total value of the industry's earnings in Brazil. Such transformations of import structure are typical of import-substitution processes, where local production leads to greater imports of intermediate and capital goods, 'upstream' the production process (Tavares, 1964).

The imports of parts and components, especially of SCC, where technical progress is embodied, play a crucial role in the development of local production of EDPE, as we shall see below in more detail. The EDPE industry's demand (for SCC) consists mainly of digital integrated

Table 1. *SCC demand, local production, imports and exports, 1978–81, in US$ millions*

	1978	1979	1980	1981
Production for the local market (1)	83.7	92.2	113.1	92.4
(Index)	(100)	(110)	(135)	(110)
Exports (2)	30.8	28.3	46.8	42.6
(Index)	(100)	(92)	(152)	(138)
Total production (3) = (1)+(2)	114.5	120.5	159.9	135.0
(Index)	(100)	(106)	(140)	(118)
Imports (4)	63.3	71.2	99.2	95.6
(Index)	(100)	(112)	(157)	(151)
Local demand (5) = (1)+(4)	147.0	163.4	212.3	188.0
(Index)	(100)	(111)	(144)	(128)
Ratios (%)				
Import content (4/5)	43.1	43.6	46.7	50.9
Export component (2/3)	26.9	23.5	29.3	31.6

Source: GEICOM.

Table 2. *Computers installed in Brazil — imported and locally produced — by class* and origin of the producer, 1978 and 1982, US$ millions*

Class and producer	1978 Value (US$10⁶)	1978 A/D (%)	1978 C/D (%)	1982 Value (US$10⁶)	1982 A/D (%)	1982 C/D (%)
Classes 1–2		(17)	(83)		(80)	(19)
A — Produced by Brazilian firms	24.2			484.5		
B — Produced by foreign subsidiaries	—			7.0		
C — Imported	120.6			116.5		
D — Total	144.8			608.0		
Classes 3–6		(—)	(73)		(2)	(54)
A — Produced by Brazilian firms	—			48.3		
B — Produced by foreign subsidiaries	267.9			945.1		
C — Imported	735.0			1175.2		
D — Total	1002.9			2168.6		
Classes 1–6		(2)	(76)		(19)	(46)
A — Produced by Brazilian firms	24.2			532.8		
B — Produced by foreign subsidiaries	267.9			952.1		
C — Imported	943.0			1291.7		
D — Total	1235.1			2776.6		

Sources: 1978 — SEI.
1982 — IEI, using the same methodology as SEI.
Note: *In terms of 1980 average prices of a sample of equipment representing at least 80% of the computer population of each class: class 1: $20,000; class 2: $90,000; class 3: $180,000; class 4: $670,000; class 5: $1,900,000; class 6: $3,000,000.

circuits (ICs). In 1981, 83% of the EDPE demand for SCC consisted of digital ICs,[10] and it was expected that this share would increase over time. Although EDPE demand represented about one-fourth of total Brazilian demand for ICs, it was supplied mainly by imports. Similar conditions apply to other sophisticated parts and components.

Therefore, in the present conditions in Brazil, there are few of the synergistic interactions between producers of SCC (and other suppliers of parts and components) and EDPE which characterize the dynamics of the electronic system in advanced countries. Figuratively, the import dependence of EDPE for parts and components highlights important 'holes' in the Brazilian 'tissue' of intersectoral linkages, which reduce the internal dynamic effects of the development of the electronics industries and reinforce the foreign exchange constraint faced by the Brazilian economy. The reliance on imports points also to a 'gap' in the national control of the industry, widened by the fact that a considerable part of such imports are intra-group operations. In this context, the Brazilian EDPE experience is especially illustrative because achieving national control over the industry has been one of the major objectives of the EDPE policy.

Using its power to control imports, the Government agency in charge of the EDPE policy has recently pressed for a greater national supply of parts and components. Although the local production of the latter is increasing (see next section), it is still limited to the simpler parts. To produce the more complex parts and components (e.g., ICs) requires further study of the resources needed for local production, scale economies, etc. It will be a major policy decision, involving complex negotiations and different interests. For instance, foreign subsidiaries may resist further import substitution not only because of the technical and economic problems involved in producing parts and components in Brazil, but also because most of their imports are transactions probably performed at transfer prices under their total control. Given the role played by the imports of parts and components in the dynamics of the EDPE industry, Brazilian-owned firms may resist it too, if they have the alternative of importing them. Such possible conflicts, to which we return in the last section, are likely to appear first in the EDPE industry precisely because it has advanced further in the process of import substitution; but these conflicts are latent in the other electronics industries as well.

The differences observed between the two industries as regards import-substitution are the result of the restrictions on imports of EDPE imposed by the Brazilian Government since the

Table 3. *SCC local production, imports and exports of discrete products and integrated circuits, 1978–81, in US$ million and percentage*

	Value				Index				Percentage			
	1978	1979	1980	1981	1978	1979	1980	1981	1978	1979	1980	1981
A. Production for the local market												
Discrete	44.2	44.2	69.2	60.9	100	100	157	138	53	48	61	66
ICs	39.5	48.0	43.9	31.5	100	122	111	80	47	52	39	34
B. Exports												
Discrete	8.8	5.6	6.2	5.5	100	64	59	63	29	20	13	13
ICs	22.0	22.7	40.6	37.1	100	103	185	169	71	80	87	87
C. Total production (A+B)												
Discrete	53.0	49.8	75.4	66.4	100	94	142	125	46	41	47	49
ICs	61.5	70.7	84.5	68.6	100	115	137	112	54	59	53	51
D. Imports												
Discrete	35.9	39.4	38.2	29.8	100	110	106	83	57	55	39	31
ICs	27.4	31.8	61.0	65.8	100	116	223	240	43	45	61	69
E. Local market (A+D)												
Discrete	80.1	83.6	107.4	90.7	100	104	134	113	54	51	50	48
ICs	66.9	79.8	104.9	97.3	100	119	157	145	46	49	50	52
F. Import content (D/E) (%)												
Discrete	45	47	36	33	100	104	80	73				
ICs	41	40	58	68	100	98	142	166				
G. Export component (B/C) (%)												
Discrete	17	11	8	8	100	65	47	47				
ICs	36	32	48	54	100	89	133	150				

mid-1970s that include the 'market reserve' policy adopted in 1977 for micro and mini EDPE systems, as well as of different local market conditions. To assess the former (and its possible extension to the SCC industry and other electronics industries), it is necessary to examine the latter in some detail, in the next section.

(b) *Growth and patterns of competition in the Brazilian market*

The growth of local markets has progressed differently in the two sectors. It is estimated that in 1976 the expenditures on electronic data processing were equivalent to 1% of the Brazilian gross internal product and that this had increased to 1.4% in 1982. The number of computers installed in Brazil increased over 15-fold between 1973 and 1982, partly as a consequence of the diffusion of locally produced microcomputers. In value terms, the installed base of computers increased 225% between 1978 and 1982 (see Table 2); and it is estimated that the EDPE industry earnings increased between 1979 and 1982 at an annual rate of 26%, despite a substantial reduction of economic activity in the country.[11]

The 300% growth of the number of installed computers in the period 1980–82 was the result of the expansion of small systems (mini- and microcomputers), which expanded at a 40% yearly rate, while the mainframe computers grew at 14% per year over the same period. Thus, in number of computers, the small systems accounted for almost 90% of the Brazilian total in 1982. However, in terms of value the position is the inverse. In Table 4, we show the estimates of SEI for the installed basis of EDPE in 1983, in which the systems are classified according to their value in six classes. Classes 1 and 2 roughly correspond to the micro and mini systems; classes 3 to 6 are mainframes (medium and large systems). Though the former accounted for 87% of the number of installed systems, their share of value was only 22%. The difference in values is more strikingly rendered if we compare the extreme classes — the first represents 73% of the number of computers but only 10% of the value; while the last (1% of the systems) accounts for 19% of the total installed value. Thus, the market reserve policy applies only to a fraction of the EDPE market that had not been hitherto occupied by MNC subsidiaries, albeit the fastest growing segment.

In comparison with EDPE, the growth of the local market and of local production of SCC has been sluggish. Over the period 1978–80, they increased 42 and 35%, respectively. This was followed by a decline in 1981 (see Table 1), probably as a result of the economic crisis, that has affected their main market (durable consumer goods) severely.[12] The market for locally produced ICs seems to have contracted sharply,

Table 4. *EDP systems in Brazil, distribution of number and value by classes of equipment, 1982, in percentage*

Class	Quantity	Value
(Average value of system) (*)		
1 (US$20,000)	73	10,3
2 (US$90,000)	14	11,6
3 (US$180,000)	8	12,6
4 (US$670,000)	2	9,7
5 (US$1,900,000)	2	37,2
6 (US$3,000,000)	1	18,6
Total	100 (24,339)	100 (US$2776 millions)

Source: SEI.
(*) Average sale value of the CPU and main peripherals. See Table 3.

while imports of ICs increased steeply (see Table 3), suggesting a mismatch between demand and supply. Since about half of the Brazilian demand for ICs is for linear circuits, of which the durable consumer goods industries are one of the main purchasers, the contraction of the latter's market and the imports of ICs (mainly digital) by the EDPE and telecommunications equipment producers probably explain this. In discrete components, the contraction of the local market and of local production is substantially less pronounced, and there is a reduction of the role played by imports, suggesting that this segment of the industry is better adjusted to local conditions.

Other important market-related differences affect the pattern of competition within and the linkages between the two industries.

In SCC, sales of domestically produced goods are heavily dependent (about two-thirds) on producers of durable consumer goods (mainly audio and TV), which are located in the Free Zone of Manaus. Most of customers are subsidiaries of multinational firms, sometimes belonging to the same group as the producer of SCC. As a consequence of the role played by the durable consumer goods demand, about 50% of the Brazilian internal demand for SCC is for discrete components (see Table 3) — (a share three times higher than the world average) — and linear ICs represent half of the demand for ICs, while the world average in 1982 was 13% (*Electronics*, 1982).

In comparison, the market for EDPE is much more diversified, as shown in Table 5, and purchasers are less concentrated geographically. However, intra-group relationships are increasing, especially between some of the main Brazilian banks (which are large purchasers of EDPE equipment) and EDPE producers.

Table 5. *The main computer markets in Brazil in number of installed computers 1981 in percentage*

Sectors	%	Accumulated
Commercial banks	24.8	24.8
Service bureaux	13.3	38.1
Trade services	6.9	45.0
Metallurgy industry	4.7	49.7
Food processing	4.0	53.7
Public utilities*	3.6	57.3
Civil construction	3.0	60.3
Education	2.7	63.0
Transport equipment industry	2.6	65.6

Source: SEI.
*Water and telephone.

The characteristics described above have several implications for the resources the firms must have to survive and prosper in the two industries. In EDPE, there is a pressure from demand to be supplied with products that are as near as possible to the 'state of the art' in a field in which fast product change is the rule; but in SCC, the bulk of demand is for relatively 'mature' products, mainly discrete or SSI components. Imports, as we have seen, supply most of the requirements for the newer and more complex SCCs. As a consequence, the capacity to supply innovations has, so far, played a much stronger role in maintaining a competitive presence in the local market for producers of EDPE than in SCC.

The technological maturity of SCC products should not be taken as an indication of absence of technology barriers to entry, since underlying such 'maturity' is a considerable degree of firm and product specific know-how and know-why. The development of this expertise is based on experience and is not easily replicable or transferable. The 'maturity' of the SCC products means that the competitive strength in this industry depends on the capacity to manufacture products of constant and reliable quality, at the level of demand requirements — i.e., a technical capability in *production* and *quality control*, which is increasingly supported by the use of semi-automated equipment, antiseptic surroundings and manpower control programs (e.g., quality control circles). Following a common pattern of behavior of SCC producers in LDCs, the firms operating in Brazil perform only part of the manufacturing operations (the 'back-end' operations) and import the products semi-finished, with one exception, which, in fact, proves the rule. This is a company where the parent had divested itself of its SCC interests, retaining only its Brazilian subsidiary, which was a major force in the local market. Thus, to survive, the Brazilian subsidiary had to become more integrated than its competitors and obtain technology from third parties, since it was not available any longer from its parent firm.

Since SCC products are very diversified (even within a relatively narrow range of families), the Brazilian market tends to be fragmented, with few suppliers for each type of product (see next section). Moreover, the determination of product characteristics requires constant contact between sellers and purchasers. The latter normally test the products for quality ('qualify' them) and require 'second sourcing.' Thus, the relationship between sellers and purchasers tends to be stable, the more so when the two belong to the same group.

As a consequence of the factors outlined above, the competition in SCC is not waged on prices, except by the local firm, which uses prices as its main competitive element. For the other companies, their parent-houses have to transfer to them the two capabilities mentioned above (quality of production and relationship to main purchasers), and the research suggests that the most successful firms in the industry are those which have developed such resources further, a process in which the local firm finds itself at a disadvantage.

The concentration of the Brazilian demand around a relatively narrow range of SCC 'product families,' the existence of a relatively large number of producers within the country and the reduction of the export incentives formerly given by the Government heighten the barriers to entry in those lines of production. The location of the main purchasers of SCC in the Free Zone of Manaus (FZM) restricts the size of the market further, since the FZM allows them to import considerable quantities of SCC, reducing the local market for present and, especially, new product lines.

In contrast, in EDPE, the technical progress of the sector coupled to the characteristics of the market, lead to a situation where competition is played out along more variables than in SCC. This produces a contradictory effect; on the one hand, firms competing in the EPDE market must have access to a wide set of resources (technical, productive, marketing, managerial) that tends to raise the threshold of entry; but, on the other hand, it opens up the possibility of market niches and different expansion strategies, that allow different combinations of competitive resources and emphasize the firm's ability to marshal such resources effectively.

For the larger mainframe products, technical and financial conditions place an insurmountable barrier to firms that are not of international size. Such barriers, which operate in every national market, are reinforced in the Brazilian case by final import restrictions and by the relatively small size of the Brazilian market. Prices are only of minor importance in the mainframe market, where IBM dominates with a 70% market share. Such characteristics are reflected in the role played by imports (mainly from the companies that have subsidiaries producing in Brazil), which accounted for over 54% of the value of installed mainframe computers in 1982 (see Table 2) and in the hefty price increase (38% in real terms between August 1981 and February 1983) imposed for IBM's 4341 system, while prices of smaller systems remained stable or declined (Tigre, 1983a).

At the other extreme of the EDPE spectrum, of desktop and personal computers, barriers to entry are relatively low as evidenced by the existence of more than 50 local producers in the market in 1983. This is due to a number of factors: the possibilities of 'reverse engineering' based upon the local supply of technical personnel and the imports of components, the relatively small role of scale economies, the rapid growth of demand and the variety of product niches. This means that the local firms combine their resources in different ways to carve out a slice of the market with different combinations of resources. Among such resources that our research suggested were important are both technical resources (which are the stepping stone to enter the industry); marketing skills, which are increasing in importance both in terms of strategic decisions (i.e., options between general-purpose products and products directed to specific markets, such as banking, and choices of marketing channels) and in terms of operational decisions (e.g., types and means of advertising).[13] The ability to provide user-friendly software is also emerging as increasingly important in Brazil, as in other parts of the world. As a result, price competition has become stronger and prices have fallen while the performance–price ratio has increased (Tigre, 1983a).

In the medium range of products, minicomputers, the combination of technical progress and market requisites has restricted the scope of growth of the products presently being manufactured. Such products require substantial technical resources for their design[14] and manufacture, as well as for the provision of software and technical assistance. The accumulation of such resources has placed a heavy strain on the local producers (see below). Although they are protected from imports, the 'concept' of the present minicomputers is far behind the international technical frontier. Thus, the price-performance characteristics of the Brazilian minicomputers are caught in a pincer movement between the supply of 'medium-size' systems from the MNCs subsidiaries and the growth of local supply of (and demand for) increasingly sophisticated microcomputers. This is a phenomenon that is occurring in other countries too, but it is especially strong in Brazil because the minis currently being produced are technically outdated. In fact, at the time of writing, eight companies had proposed to produce in Brazil the 32-bit superminis, pending a decision of SEI.

The pattern of competition observed in the EDPE market rests upon two pillars: the possibility of importing technical progress built into components, and the market segmentation

which protects the markets of mini- and microcomputers from the competition of imports and products of local subsidiaries of multinational companies. Should either of the two pillars be removed without countervailing measures, the present structure of the industry would collapse.

(c) *Exports*

Exports fulfill different functions in the two sectors. While they account for an important share of local production of SCC (about 25% in the period 1978–81), they represented only 12% for the EDPE earnings in 1982.[15] However, such aggregate figures disguise important differences. In SCC, exports are an important outlet only for the local production of integrated circuits, most of which are exported (see Table 3); in EDPE, exports are made mostly by the subsidiaries of foreign firms, which export about two-thirds of their total production of mainframe systems. Although the Brazilian EDPE firms have been able to exploit some international market niches, such as, lottery terminals exported to another Latin American country, several factors limit their exports. Especially important seem to be the comparatively high cost of their products relative to international prices, and the need to provide foreign customers with technical assistance and services over a language barrier and the cost of setting up such services.

The Brazilian Government has used two main policy instruments to foster exports of electronic products: fiscal incentives and conditioning imports of parts and components to exports of finished products. Such policies seem to have been successful in the case of multinational companies, probably rendered easier by the fact that most of such exports are intra-group operations. However, in the case of local companies, such instruments are probably insufficient. Even if such firms can produce at international prices, they will probably require a wider set of policy instruments to overcome the cost barriers of entering foreign markets.

3. LOCAL PRODUCERS: FOREIGN-OWNED AND BRAZILIAN FIRMS AND GOVERNMENT POLICIES

In contrast to other import substitution policies, which had as their main objective replacing imports by local production, the EDPE policy includes the control of such production and its technology by Brazilian-owned firms. Except in micro- and minicomputers where this policy has been applied, MNCs dominate. In mainframe computers, IBM controls over 60% of the value of the 1982 installed base, followed by Burroughs (14%) and CII-Honeywell Bul (7%). In SCC where at the time of the research there were 17 producers, only one was a relatively small national firm producing LEDs. The four main producers of SCC accounted for over two-thirds of total sales in 1980, but concentration varied considerably between specific products. For instance, in 1981, the transistor type TO-92, widely used in the consumer goods industries, was produced by at least five firms; however, digital integrated circuits were produced by two firms only, one of which exported its whole output.

Brazilian subsidiaries rely upon their parent firms (or other subsidiaries[17]) for innovations and for a substantial part of the resources needed for production (technical know-how, machinery and equipment, parts and components). They differ, however, in terms of the extent to which they have 'internalized' the stages of production. In SCC, only the final part of the production process is performed locally. Because most of the assembled parts are imported, linkages to local suppliers are very limited. In EDPE, Government policies have led to the establishment of a network of local suppliers of parts and components. IBM, for example, in 1982 used about 370 suppliers for 3800 parts and components.[18] Apparently, the value of local purchases is equivalent to its imports of parts and components. IBM provides production know-how to such suppliers, but not the reasons for the specification of the products. In the recent past, the subsidiaries of EDPE have also increased their purchases of peripherals produced by local firms on OEM[19] contracts. Because of their scale, such contracts may be very important for local producers of peripherals but, at the same time, they also pose a threat by making local producers dependent on the purchases of the subsidiaries. The evidence available so far is insufficient to evaluate the amount and type of technology transferred from the systems producers to their peripheral suppliers.

The activities the subsidiaries have developed further in Brazil are those related to sales (marketing and technical assistance), that must necessarily be conducted from within the country. As shown in Table 6, about half of the university-trained personnel of the EDPE subsidiaries were employed in such activities; an additional third were used mainly in administrative tasks ('others' in Table 6). However, the skills that the parent firm transfers to the subsidiaries are mainly for the routine operation of such activities. Strategic decisions (e.g., as

Table 6. *Employment of university-trained personnel by activity in foreign subsidiaries and Brazilian-owned firms, in 1979 and 1982 by percentage*

Activities	Subsidiaries 1979	Subsidiaries 1982	Brazilian-owned 1979	Brazilian-owned 1982
Marketing	44	40	27	31
Support services	8	7	5	11
R&D	3	4	31	27
Production	11	15	14	14
Others	34	34	23	17
Total	100	100	100	100
(Quantity)	(2521)	(2697)	(1531)	(4027)

Source: SEI, IEI elaboration.

regards the composition of the product line) and the knowledge underlying such decisions remain concentrated in the parent firm. In fact, one of the complaints of the local EDPE firms about the marketing executives they have hired from their foreign competitors is about their lack of a strategic decison-making capability.

As a consequence, the contribution of the subsidiaries to the development of an 'industrial tissue' is limited, especially in SCC. Thus, the Brazilian firms that entered the EDPE industry could not rely on externalities created by the subsidiaries, especially in the beginning of the present phase of development of the industry (from 1977 onwards), since the same policy of market reserve that led to their inception was responsible for the greater involvement of EDPE subsidiaries with local suppliers. In fact, the Brazilian-owned firms were faced with an undeveloped supply of resources, both human and material, for their activities of innovation, production, marketing and technical services. Imports have alleviated such deficiencies but they do not generate the network of local relationship that produce externalities and synergism characteristic of the EDPE industry in more advanced countries.

Moreover, imports have been used mainly for material resources. As shown by Piragible, Tigre and Pena (1983), human resources in the Brazilian EDPE firms are developed mainly in-house and on-the-job, with the costs borne by the enterprises.[20] As shown in Table 6, such enterprises have increased their employment of university-trained personnel 263% between 1979 and 1982.[21] The evolution of the distribution of university-trained personnel shown in Table 6, indicates the considerable effort such enterprises are making in R&D activities,[22] as well as the increasing importance of market-oriented activities in the Brazilian pattern of competition. Because such human resources tend to move from one enterprise to another, the firms that invest more in training tend to generate externalities to the others. In such cases, the social and entrepreneurial calculus tends to differ, but the Brazilian Government policies give no premium to the enterprises that invest more in training and employment of highly skilled personnel.

Thus, the Brazilian firms have been obliged to internalize a substantial part of the cost of developing the resources necessary for their activities, but under three restrictive and interrelated conditions: (1) their relative small size; (2) the virtual competition of imports and local foreign subsidiaries; and (3) the deficiencies of the Brazilian market for risk capital.

The three factors are interrelated, but probably the most important is the possible competition from imports and subsidiaries. The Government policy of market reserve, which generated the locally owned firms, was feasible only because, at the time of the decision in 1977, no local subsidiaries were producing the protected products. It is unlikely that, if such a market had been occupied by a subsidiary, the Brazilian firms would have resisted the competition and that the Government would have excluded the subsidiary from the market. The pressure of the subsidiaries and their parent companies against the reserved market policy has been enormous, and it has found support from customers dissatisfied with the goods and services supplied locally and from firms that use other electronic products, mostly imported, which fear that the EDPE policy may be extended to other products (e.g., the MNC subsidiaries producing automobiles).[23]

The opposition to the reserved market policy has been waged on both ideological and eco-

nomic grounds. The former argue primarily against State intervention in the economy; and the latter base their opposition on the higher costs EDPE users must pay because of the policy. The first argument strikes at the very heart of the policy because if carried to its ultimate consequence, it would lead to the elimination of the local industry by imports and foreign subsidiaries. The economic and political arguments for and against such a situation are well known and need not be reviewed here. It is perhaps sufficient to recall that on balance, in most industrialized (and semi-industrialized) countries such arguments have led to active State intervention to foster local electronic industries. The costs to customers of 'infant industries' and the differences in the evaluation of both costs and benefits between such customers and policy-makers, are also well known. In the case of the Brazilian EDPE, the main costs to customers are the use of products that have a higher price/performance ratio than products supplied in the advanced countries. The little evidence available suggests that the price differential between products manufactured in Brazil and in the US is substantial, despite a decline recently observed in real prices of the Brazilian products, especially in microcomputers (Tigre, 1983a). However, it is important to stress that such a differential applies to products supplied by multinational subsidiaries, too, and occurs in many other industries, suggesting that its cause may lie in more general aspects of Brazilian industry rather than on the specific EDPE reserved market policy. It is also worth mentioning that, although there are complaints about the relative outdatedness of the locally produced equipment, especially for minicomputers (see below), there is little evidence that such a technological gap creates a serious productivity bottleneck for their users.

Against such opposition, strengthened by the objections of some Government agencies to what they see as SEI's expansion into their areas of influence (see next section), the market reserve policy has been strongly backed by the technical and scientific communities and several State agencies (which include many customers of the local products), especially those with stronger nationalistic orientation such as the Armed Forces, and SEI and the Brazilian-owned EDPE industry. As we have argued in more detail elsewhere, it is only when this type of interest coalition is formed, structured not only by economic but also long-term political objectives, that a policy that aims at greater technological self-reliance can be implemented in an LDC (Erber, 1977). Nonetheless, the EDPE reserved market policy remains highly controversial; and although it has been maintained, it lies constantly under a cloud of uncertainty.

To such uncertainty must be added the deficiencies of the Brazilian capital market. The main source of long-term funds for industry in Brazil, the National Bank for Social and Economic Development (BNDES), only recently included the EDPE industry among its priorities. Although BNDES, some of the regional development banks and other Government agencies hold equity interests in some of the minicomputer producers, notably Cobra, they have been reluctant to increase their capital. As for private sources, the contribution of the stock exchange and of venture capital institutions has been quite limited. Direct investment by large groups, which have the resources for supporting the growth of the EDPE enterprises and which could be attracted by the industry's growth at a time of few investment alternatives, has been directed primarily to production of banking systems and peripherals by a few wholly owned subsidiaries. Such investment is being made mainly by two large commercial banks that use electronic services extensively,[24] and by one conglomerate that is diversifying into electronics. Although several commercial banks hold equity in some of the minicomputer makers, they have also been reluctant to supply additional capital. For the majority of EDPE producers, the main sources of funds have been their profits and the very expensive commercial credit.

Under such conditions, it is not surprising to find that the Brazilian firms tend to labor under intense financial strain, especially the producers of minicomputer systems, that have to bear the expenses of a relatively larger organizational structure of R&D, technical services and marketing.[25]

Despite such constraints, the local industry has progressed noticeably in its five years of life. At the end of 1982, it comprised more than 80 enterprises, employing more than 15,000 people (of which more than 30% are university-trained) and with a third of total EDPE earnings of that year (US$1.8 billion). Such enterprises have developed capabilities in production and marketing and mastered important skills in the areas of product design and development (see below). As mentioned, the price-performance ratio of their products shows a trend to increase, and they have recently improved their after-sales services considerably. Nonetheless, the Brazilian-owned EDPE industry faces considerable problems in the near future.

The most important obstacles to the survival and growth of the Brazilian EDPE industry center around its ability to update product lines

to meet the demands of purchasers whose standards are at the international technological frontier. This has to be done in face of virtual import competition and local production by international firms. Although the Brazilian market may live with a technological gap, this has limits beyond which the combined pressure of purchasers and competitors may lead to a reversal of the present market reserve policy.

The need to update the product lines renews the 'infant industry' problem the enterprises have been facing — the necessity to build a stock of resources at the same time that the services of such stock are being used. Given the rate of technical progress of the EDPE industry, such problems are unavoidable and they require a policy of managing the technological gap carefully.

In the recent past, the Brazilian firms have followed a strategy of technological development that combines several features: formal licensing contracts, copying and adaptation without contracts, endogenous development and imports of components. Formal licensing linked to a systematic R&D effort is more frequent in the minicomputer makers; on the other hand, microcomputer producers use a copy-and-adaptation approach, coupled with the import of components.[26] Both strategies pose significant problems.

The first strategy has provided local firms with a capability to design, manufacture and service the old generation of minicomputers. However, there are strong doubts whether such capability is sufficient to make the transition to the 32-bit supermini generation. Of the eight enterprises proposing to supply the Brazilian market, five have proposed to do so based on licensing agreement; three others, including Cobra, are basing their proposals on their own technology.

Although the Brazilian EDPE spend more on R&D than the United States average in terms of share of sales (an average of 11% over the period 1979–82) and a similar amount per employee (US$5346 in 1982 for the leading 15 firms), and although they allocate 30% of their university-trained personnel to R&D activities, there seems to be a threshold problem linked to the size of such enterprises, especially if they want to be at the frontier. As an example, Cobra, the main producer of minisystems and the technological leader of the industry, invested in R&D in 1982 about US$ ten million, less than one-eighth of the expenditures of Data General, the second largest producer in the United States. A 'gap strategy' reduces the threshold problem, and licensing reduces it further, since licensing of 'middle-aged' products tends to be easier and less expensive. Government funding of such expenditures, a rule in other countries, has been limited in the Brazilian case and would, of course, also reduce the problem. So would joint action by the Brazilian producers, a common feature in more advanced countries, (such as Japan), which has not been used in Brazil yet, but which is being suggested for the super-minis in one proposal presented to SEI. Nonetheless, the R&D threshold, combined with other activities when there are scale constraints such as marketing and technical services, may lead to changes in Government policies, entrepreneurial strategies and in the structure of supply of the Brazilian industry.

Producers of microsystems have had to invest less than makers of minisystems, because of their ability to perform reverse engineering (in itself an indication of technical capability) and to import the necessary electronic components. However, the trend of leading international microcomputer producers to use custom-made ICs jeopardizes this strategy unless the Brazilian microcomputer makers learn the skills of chip design and order their own chips. However, this represents a quantum leap in their present technical capability and raises again the threshold problem and its implications in terms of size of enterprises and industry structure. Under the present conditions of the Brazilian SCC industry, such chips would have to be imported. An important issue in the SCC policy is whether local production should include design and manufacture of semi-custom chips (see next section).

Five years of life in an industry, as in human beings, is still early infancy, and it is certainly too soon to pass a judgment on the Brazilian EPDE experience. As shown by Bell (1982), some industries take as long as human beings to mature, if by 'maturing' one means achieving international competitiveness. It is arguable whether this is the right concept of maturity, as it is at least as laden with values as any other alternative concept (e.g., ensuring national control of decisions).[27] One might also argue that the latter objective is worth paying the price of less international competitiveness. Nonetheless, in the Brazilian conditions, the success of the present policy and the viability of the Brazilian industry seem to depend upon reducing the costs of updating its products over time as a consequence of static and dynamic scale economies. The evidence available suggests that learning has had an important impact on Brazilian industry, which has developed substantial technical and industrial capabilities. The problems identified above do not imply that the industry is not viable and that the policy of market reserve should be reversed. However, they do suggest that market

protection is not sufficient, although it is clearly necessary; other Government policies, such as R&D and training support, and some restructuring of the industry may be necessary.[28] Moreover, they also suggest policies that may be useful not only for the Brazilian EDPE industry, but also to the Brazilian SCC industry, which the Government intends to foster now.

4. GOVERNMENT POLICIES FOR THE SCC INDUSTRY AND THE 'ELECTRONICS COMPLEX'

Until recently, the Brazilian Government policy for electronics was strictly sectorial and concerned mainly with the final-use products. Thus, the Ministry of Communications looked after the problems of supply of telecommunications equipment, CAPRE[29] was in charge of EDPE, and there was little coordination between them. For SCC products, which provide the main linchpin of the 'electronics complex,' there was no policy, and their development was left to the market.

As a result of several market-related factors, such as a rising demand for durable consumer goods (fueled by a phase of great economic expansion and increasingly skewed personal income distribution) and of policies such as the fiscal incentives to consumer goods plants in the ZFM (which included tariffs on imports of SCC), the local supply of SCC was heavily biased toward the durable consumer goods market. In other sectors where Government agencies played an important role as purchasers and controllers of imports (telecommunications, defense), the final purchasers were left relatively free to import the SCC they needed. Export incentives of a fiscal nature seem to have been important for the establishment of some export-oriented plants. However, as we have seen, the output of such plants seems to be loosely connected to local market needs.

Thus, even if there was no 'explicit policy'[30] for SCC in Brazil, Government measures normally taken with other objectives, such as regional development, played an important role in shaping the present structure — a typical example of the importance of 'implicit' policies in industrial and technological development.

Policy-making for the electronics industries in Brazil, even where it existed in an 'explicit policy' sense as for EDPE, was further characterized by the limited number of instruments used. As we have shown above, the policy for EDPE until recently relied almost exclusively upon the control of imports and made little use of instruments such as the Government credit system and fiscal incentives (except for exports), which were widely used for other sectors.

More recently, this picture of policy fragmentation has begun to change. In 1979, the Government replaced CAPRE by the Special Secretary of Informatics (SEI), attached to the National Security Council, and broadened its policy-making mandate to include automation, instruments and microelectronics, besides all activities related to EDP hardware and software. At the same time, some steps were taken to increase the funds for electronic products within the BNDES system and a Center for Informatics Technology (CTI) was set up by SEI, near the universities of Campinas and São Paulo and the R&D Centre of Telebras.[31] The main objectives of such centers are to develop electronic products locally and 'pioneer' their production, until private enterprises are ready to do it. These measures are directed at two of the main weaknesses observed in the policy for EDPE: financial resources and technical capabilities. It is, however, much too soon to evaluate the results, although there is the suspicion that the amount of resources available may be insufficient to overcome the obstacles observed.

SEI has also defined a policy for SCC that bears some similarities to that put in practice for EDPE and that may benefit from the criticisms of the latter. The objectives of SEI are to enable Brazilian-owned firms to design and produce locally some types of SCC. There are two main reasons for the priority given to digital integrated circuits; first, technical progress will tend to increase their relative importance; and, second, the presence of multinational subsidiaries in less strong in this area in Brazil than in discrete products. To overcome scale problems, custom and semi-custom ICs are emphasized, rather than products manufactured on a large scale, such as memory components and microprocessors. Moreover, the two local firms SEI has selected to negotiate entry into the SCC market are large groups with considerable financial and technical resources that are already successful producers of EDPE peripheral and banking-systems products. At the same time, SEI has taken steps to discourage the expansion of MNCs in the ICs area in Brazil and has purchased for its own Technology Center (CTI) the whole line of IC production of one of the EDPE MNC subsidiaries. Finally, SEI has received additional powers to control imports of SCC, not only for EDPE but also for other sectors. These are, however, still in the process of implementation, especially as regards imports for the ZFM, which were previously authorized by another Govern-

ment agency. Negotiations between SEI, and the two local groups are still underway. The latter's strategy seems to be to give top priority to the development of their design capability, which is essential for custom and semi-custom production, and to import semi-finished products for final elaboration. It is too soon to assess their ability to enter the market successfully and to stay competitive.

The policy for SCC suggests that the experience of the EDPE industry has resulted in learning in terms of policy-making. The policy for the two sectors shares the feature of segmenting the market according to product lines and reserving some lines for national firms by excluding the participation of foreign subsidiaries and imports. They have also in common the attempt to reduce head-on clashes with foreign companies by not encroaching upon their main present markets. However, since the two policies try to reserve for the national firms the most dynamic markets within the industries, the conflict is unavoidable. As we have seen, the SCC policy seems to be trying to avoid some of the problems caused in EDPE by a relatively large number of enterprises in comparison to the size of the market, by financial weakness of enterprises and lack of a technical infra-structure.

It is possible, however, that the experience of EDPE may have led to an overestimation of the role played by import controls in making a local industry viable. Since EDPE are end-use products, the control of their import at a time of increasing demand created a market for the local products almost automatically. Although the policy had to bear the burden of consumer dissatisfaction for buying products more expensive than imports, it could leave to the market the process of matching the technical requirements of purchasers and sellers.

This will be more difficult to do in the case of SCCs, since they are part and parcel of the design of the products that use them, at a time in which there is a trend to inscribe in the electronic components an increasing part of the characteristics of performance and reliability of the final product. Therefore, a policy for SCCs cannot be considered independently of a policy for the products that use them, especially if the SCC policy places restrictions on the sources of supply, as the present policy will do through import controls, limiting the number of local suppliers and restricting the action of foreign subsidiaries. Such restrictions will place a heavy burden on the design capacity of the end-use products manufacturers, especially if they use imported designs and/or imported components. The ensuing conflicts are likely to be considerable, because not only multinational companies, which have worldwide standardization of design and supply of SCC, will be affected by the restrictions, but also the Brazilian firms that import and adapt designs. The firms that develop their own designs but that use imported components may object to the policy too, as well as purchasers of electronic goods and services if the policy results in price and/or technology gaps. The EDPE industry and its customers is a case in point because, as we have shown above, it relies upon a combination of local design and imports of components.

Thus, because of the place SCC supply occupies within the electronics complex, the policy presently envisaged for the industry may most likely repeat the problems we have seen for the EDPE industry in an expanded dimension. Local producers of SCC will face 'infant industry' problems similar to those experienced by their EDPE counterparts. Although they may learn from the latter's experience and have better initial conditions in terms of technical skills and finance, the evidence available suggests that, in an LDC, 'infancy' problems tend to be renewed in a rapidly changing industry that is not run by MNCs.

Probably the greatest challenge posed by the SCC policy is not to the local producers but to those in charge of the policy. Policy-makers must combine several difficult components. First, they must combine comprehensiveness with selectivity and flexibility, in the same way as the electronics industries form a interdependent system where each part has its own pace of development. The need for flexibility and selectivity are illustrated by our previous discussion of the technological gap and of imports of technology and inputs. The EDPE experience shows that there is a limit to the differences between local and international products in terms of price-performance, variety and quality of products, beyond which the combined pressure of customers and excluded competitors becomes irresistible. The importance of such gaps between local and international average practices will vary according to products and over time for the same products, requiring selectivity and flexibility for their management.

The two conditions above are, to some extent, part of the tradition of the Brazilian state bureaucracy. What may prove more difficult to cope with is the requirement of comprehensiveness. This requirement may be understood in two senses. The first, derived from the inter-industrial network of relationships, requires that the policy for SCC be designed and implemented at the same time as policies for other electronic products. The second is derived from the set of

activities an enterprises must perform to deliver its product to the market (R&D, production and marketing) and the different instruments the Government may use to influence the development of such activities and their outcome — credit for R&D and fixed investment, purchase policies by State enterprises and other steps. In practice, comprehensiveness must be exercised in the two ways, and it amounts to an explicit and articulated industrial policy, something Brazil has not had for the past quarter of a century.

Such industrial policy must accommodate the many inevitable conflicts that developing an electronics complex in an LDC will generate. Conflicts will exist between State agencies, between local and foreign producers, and between customers, all along the lines of the network of relationships structured by the electronics complex. The elaboration and implementation of such policy cannot be left to bureaucrats and entrepreneurs alone, since it involves so many different interests. In this sense, too, electronics presents one of the most important challenges to Brazil: to develop and implement an industrial policy within a democratic framework.

NOTES

1. For a fuller discussion of this concept of 'industrial complex' and its relationship to the different concepts of 'industry', see Erber (1983).

2. See Erber (1980) and references therein for the experience of the more advanced countries.

3. Tigre, Piragibe and Erber (1984), Macknight and Erber (1984), Erber (1983). See also Piragibe, Tigre and Pena (1983) for a study of human resources in the EDPE industry and Tigre (1983a) for the development of price-performance ratios in the EDPE industry. Macknight (1982) and Tigre (1983a) present earlier studies of the SCC and EDPE industries. Piragibe (1984) analyzes in greater detail the development of the EDPE.

4. The first firm to produce EDPE in Brazil was IBM in 1961, followed by Burroughs in 1967. Both had subsidiaries since 1924 and had been producing electromechanical office equipment since 1939 and 1953, respectively. The first two firms to produce SCC in the country, in 1965, were Philco (Ford) and Philips, which had subsidiaries in Brazil since 1950 and 1960, respectively.

5. Among other reasons, labor costs in Brazil were higher than in other LDCs, especially Southeast Asia countries (Macknight, 1982).

6. In contrast, the Brazilian market for ICs is only 1% of the US market. This highlights the differences in the structure of production of electronics products, dominated in Brazil by the durable consumer goods (see below).

7. Data for imports in SCC have to be taken with great caution since they do not include the imports of components contained in imports of finished products. Moreover, there is considerable illegal import of SCC especially of ICs. Both would raise the ratio considerably. A considerable number of microcomputers has also been illegally imported.

8. Most of the mini and microsystems fit into classes 1 and 2 of the classification used by the Special Secretariat of Informatics (SEI-Secretaria Especial de Informática), the Government Agency in charge of the informatics policy.

9. Grupo Executivo Interministerial de Componentes e Materiais — Interministry Executive Group for (Electronic) Components and Materials.

10. Linear ICs represent a negligible share of the demand, the rest being accounted for by discrete components. Estimates based on GEICOM data.

11. During the 1977–82 period, Brazilian gross internal product declined 1.3% yearly in real terms, while the industrial product declined 4.1% (Malan and Bonelli, 1983).

12. Between 1980 and 1981, the sales of radio and TV sets dropped from US$1850 million to US$1650 million (Wajnberg, 1982).

13. See Table 6 for the use of university-trained employees.

14. Most of them have been locally designed and/or adapted. See below.

15. This excludes exports of products imported under draw-back clauses, which correspond to about 20% of the exports.

16. Exports of discrete components amount to about one-tenth of total production, as can be seen in Table 3.

17. For example, IBM imports SCC from plants of the group located in the US (Fishkill and Burlington), France and Japan.

18. The company's policy is to qualify at least three suppliers per part.

19. Original Equipment Manufacturer. Such contracts provide for exclusive supply of some peripherals to the producer of the EDP system.

20. This does not apply to the basic technical training of the staff of the enterprises. One of the factors facilitating the development of the Brazilian industry was the existence of locally trained engineers.

21. In the same period, the employment by MNCs subsidiaries increased 7% (see Table 6).

22. Compare the share of university-trained personnel used for R&D activities in the locally owned firms and the foreign subsidiaries in Table 6. The share of the former is at least six times greater.

23. The struggle against the market reserve policy has used many instruments from local press campaigns to direct pressure on the Brazilian Government, including pressure by the parent firms on their own Governments to exert their influence on the Brazilian Government. One of the most recent rounds of the fight has taken place in the course of the renegotiation of the Brazilian external debt, by the US and Brazilian Governments. (See Tigre (1978) and Data News (1983) for details.)

24. The demand from the banks which own the EDPE producers reduced the risk of such investment considerably. Nonetheless they are now spreading their investment in electronics.

25. In 1981, Cobra had a gross earnings margin over the cost of production of 47%, similar to that of the subsidiaries. However, financial expenditures took up 90% of such earnings. Since then, new equity capital has improved its financial structure but it is still highly undercapitalized.

26. Those are 'stylized facts.' Import of components are essential to minicomputers and microcomputer producers also do R&D.

27. This does not imply that concepts of maturity (i.e. the economic, social and political objectives, which are behind the concept) are equivalent but only that they are dependent on values and not supposedly 'neutral' and 'objective' as much of the literature has it.

28. The UK, France and Japan present examples of such policies.

29. Comissão de Atividades de Processamento de Dados — CAPRE was in charge of the EDPE policy from 1972 to 1979, when it was replaced by SEI, Secretaria Especial de Informática.

30. The distinction between explicit and implicit policies, i.e., between policies which are from the outset directed to some activities and those which have been designed for some other purpose but influence other activities, is widely used especially in the analysis of science and technology policies, where the latter are usually considered to be more important than the former.

31. The two universities mentioned are the main academic centres for electronics, besides the Federal University of Rio de Janeiro and the Technological Center of the Air Force, located not far away. Telebras is the Government enterprise in charge of communications and its R&D center has an ambitious program of developing electronic products.

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