THE COMPUTER QUESTION IN BRAZIL: HIGH TECHNOLOGY IN A DEVELOPING SOCIETY

papers edited by

Antonio Botelho
and Peter H. Smith

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C/85-4

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July 1985

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INTRODUCTION

Can a developing society create and sustain its own computer industry? What are the costs and benefits of an attempt to do so? What kind of economic policy can (or must) the state adopt? Who stands to gain--and who stands to lose? Is there any such thing as an "appropriate" high technology?

These questions become especially salient in reference to Brazil, where the national government in 1984 promulgated a law banning the importation of minicomputers and, in effect, reserving this segment of the market for domestic manufacturers. The strategy provoked instant and widespread controversy. Multinational producers claimed that the exclusion was unfair and counterproductive, that it would doom Brazilian consumers to obsolescent (and expensive) equipment, that it would favor only one small segment of the local business class. U.S. government officials denounced the law as prejudicial to American interests and contrary to the principles of open trade. Brazilians responded by proclaiming the critical importance of a locally-controlled computer industry and by asserting that Washington is merely seeking to protect the oligopolistic privilege of IBM, Burroughs, Apple, and other major U.S. corporations. The debate has drawn considerable attention as other countries, particularly Argentina and Mexico, strive to define their own stance on similar questions.

Where lies the truth? To examine these issues the

Massachusetts Institute of Technology held a syumposium in April 1985 on "The Computer Question in Brazil: High Technology in a Developing Society." More than 100 people attended: most were from the Boston/Cambridge area but some came from New York and Washington, while three of the panelists made the trip from Brazil. The audience included engineers, economists, political scientists, government officials and business representatives. Discussion throughout was vigorous, sustained, intense.

The papers in this collection come directly from the conference (with only minimal editing on our part). In the leadoff essay, Simon Schwartzman argues that the 1984 informatics law was consistent with the historical trend of Brazilian industrial policy, that it is not a temporary aberration: it will face political and economic challenges, as he so clearly points out, but it will be here for some time to come. The question is not whether Brazil will have its own computer industry, but what kind it will turn out to be.

In a similar vein, Peter Evans demonstrates that the formulation and implementation of the informatics law has been contingent upon the consolidation of specific sociopolitical alliances that have, over the years, promoted a variety of nationalistic arguments. Ideology and politics have been essential to the success of the strategy so far, and they--along with economic factors--will no doubt play key roles in the future.

Finally, Paulo Bastos Tigre offers an economic evaluation of the performance of the Brazilian computer industry to date. Challenging widely held assumptions, he demonstrates that local products have rapidly gained in price competitiveness, at least with regard to CPUs (central processing units). And as Tigre argues, the question of "obsolescence" depends upon the standard for assessment: Brazil might or might not require the latest development in the U.S. or European markets, so the real issue is not obsolescence per se--it is suitability and usefulness.

We want to extend our thanks to moderators and commentators at the MIT symposium: Carl Kaysen, Beatriz Nofal, Charles Sabel (all of MIT), Richard Graham (University of Texas), and Ricardo Saur (Brazilian Association of Computer Manufacturers/ABICOMP). We want to acknowledge the support of institutional sponsors from MIT: the Program in Latin American Studies, the Program in Science, Technology, and Society, the Department of Political Science, and the Center for International Studies. And most especially, we want to express our appreciation to Mr. and Mrs. Eli A. Grossman, without whose encouragement and generosity we would never have been able to carry out the project.

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Cambridge, MA
July 1985

HIGH TECHNOLOGY VS. SELF-RELIANCE: BRAZIL ENTERS THE COMPUTER AGE*

Simon Schwartzman

By the end of 1984 a bill defining a "national policy for informatics"[1] was approved by the Brazilian Congress by a large majority of votes from government and the opposition parties. It was preceded by a lively debate reminiscent of the period before the setting up of the country's oil state monopoly and Petrobrás in the early fifties. Once more the issue was presented as a dilemma between national autonomy and self-determination, on one hand, and control of the country's resources by international companies and their local associates on the other. Once more the campaign gathered intense support, from nationalist military groups to intellectuals and left-wing political parties.

It is remarkable that the Law of Informatics was approved in the twilight of the military regime, when most of its ambitious projects of the Seventies had already proved monumental fiascos. The true extent and reasons for this disaster are still to be evaluated. The official line was to blame the oil shocks and high interest rates, which put the country's external debt and internal inflation almost out of control, and forced the implementation of recessive policies. But there were also over-ambitious projects, like the nuclear program, the "steel railroad" between Minas Gerais and Rio de Janeiro and the hydroelectric plants of Itaipu and Tucurui; unrealistic optimism, like the one surrounding the Carajás project; and sheer mismanagement and corruption, like in the naval industry program. All these elements played some part. The fact was that charges that the State bureaucracy's policies were wasteful, inefficient, and corrupt abounded and played an important role in the political change that led to Tancredo Neves' election to the Presidency in early 1985.

*Paper presented for the M.I.T. Symposium on "The Computer Question in Brazil," Cambridge, Mass., April 16, 1985.

The national "informatics" policy (we shall refer to it in the acronym PNI), however, was not affected. In spite of being a governmental project with strong military backing, it also had support in the academic community, and was presented as a purely national project based on private enterprise, making use of national competence and confronting the pressures of multinational interests. At the end, it drew opposition from the official candidate to the presidency, Paulo Maluf, who was already politically isolated, and support from his winning opponent. Thus, from a political standpoint, the "informatics" law was some kind of paradox, and a remarkable political achievement.

In this article we try to show that this policy and the institutions it created are not an anomalous or extraordinary event in Brazil, but are well ingrained in the country's policy-making tradition. Nationalism, we will contend, is its most apparent feature, but not the most important one. Once we understand the origins of this policy, we can draw a picture of the main actors involved in shaping it, how they act and what they have been able to achieve. With these elements, we might be able to speculate about the current strengths and weaknesses of PNI, the problems it may have and what one can expect about it in the near future.

1. Framework

The role of the State in promoting industrial development in Brazil has been a constant feature in the country's recent history, and has been subject to detailed scrutiny (see among others Leff, 1968; Martins, 1976; and Wirth, 1973). In some cases, this role has been exerted by the creation of companies owned and run as part of the state's administration, like the Volta Redonda steel mill in the Forties and Petrobrás in the Fifties. In many other instances, the government provided privileges and protection to private groups to run their own in-

dustries, creating fiscal barriers for competitive imports, providing special tax exemptions and credit facilities.

When the State gets involved in industrial promotion it affects not only the amount of goods produced and the distribution of wealth in society, but the country's whole social and political fabric - how interest groups are established, how class conflicts are carried on, how the political parties behave, and how government itself is organized and run (see for instance Gershenkron, 1962; Polanyi, 1957; and Bendix, 1956). An excellent framework to understand this complex reality has been recently proposed by Edson de Oliveira Nunes, who suggests that Brazilian politics and policy-making should be understood in terms of four different and shifting "grammars", namely clientelism, corporatism, bureaucratic insulation and procedural universalism (Nunes, 1984).

One could say, accordingly, that since the Thirties Brazilian industrialization and economic modernization have been promoted typically by administrative groups acting under bureaucratic insulation, as a protection against clientelist distributivism, or a way to assure control of some key resources against foreign or private interests. As a given policy develops, new actors are called in, and corporatist structures are put forward to discipline and control the interests involved. In a later stage, there are pressures to generalize access of different actors and interest groups to new fields of activity. In some cases, as in the development of the country's automobile industry and other projects during the Kubitschek government, the policies were carried on by "executive groups" with full authority and working directly under presidential supervision. For the automobile industry, special benefits were provided for large multinational corporations to establish themselves in the country. Competition among the companies was regulated, nationalization targets for components were set, and salaries were controlled by the country's corporatist labor legislation. Entrance of new companies was not allowed (except later for Fiat, which accepted to get established in Minas Ge-

rais and got strong backing from that state's government). A different example is oil production. Here, the policy of excluding private groups and foreign companies started in the Thirties, and resulted in the creation of Petrobrás in the Fifties, as a state-controlled company with legal monopoly over the oil industry. (Some residual place was left for private and foreign companies for refining and retail distribution, under close governmental control).

Whether bureaucratic insulation leads to policies of one of those two types is neither trivial nor inconsequential. A prerequisite in both cases is the existence of an active group with political access which can get support at the highest possible levels, without going through the more traditional channels of clientelistic politics - which usually means to avoid Congress and the political parties. In some cases, this group comes from a more "modernized" sector of the State's administration, including the armed forces. In others, it comes already with strong links with private, national or foreign interests, and acts as "bureaucratic rings" linking public and private interests. In the first stage of a new policy, the characteristics of this group are probably crucial in determining its policy's content and orientations. At latter stages, however, all will depend on its capacity to put foward its ideas, the other interests that get involved, and the whole political climate in which decisions are taken.

Here again the example of oil is interesting. In the Thirties Monteiro Lobato, a well known intellectual and entrepeneur, organized his own company to find oil in Brazil and drew the wrath of officials in government who wanted to keep oil extraction under state control. Lobato accused the administration of working in alliance with American companies to keep Brazil out of oil production, and tried to associate with German interests (later, he became a symbol of economic nationalism and is considered one of the forefathers of Petrobrás). It is possible to identify, behind these differences in policy, the clash of groups with different institutional and even regional

origins.[2]

Corporatism functions as a mechanism to define who should participate, and what benefits they should get from that participation. This expression is often used to characterize the relations between workers and employers in Brazil, which are minutely regulated by law and supervised by the State. Its scope, however, is much larger, including a wide range of special privileges granted to citizens with some specific qualifications (usually university diplomas) and benefits, subsidies and other forms of special treatment provided to some economic groups, in exchange for close governmental supervision and control.

Corporatism and bureaucratic insulation are useful to protect specific projects and institutions from political patronage and universalism. Few people are openly in favor of political patronage or clientelism, that is, the distribution of public jobs on strictly political grounds, with total disregard for the recipients' qualifications and entitlements. Universalism, however - the notion that there should be no special monopolies and privileges, but open competition based on merit and competence - is a much more legitimate stand. Bureaucratic insulation and corporatism can easely function as protections for inefficiency and privilege, hidden under the banners of patriotism or national security. In order to have competition, however, one should have competitors, and it certainly makes sense to try to build them up in the country instead of paying the price of opening it fully to foreign interests without appropriate restraints and controls.[3]

2. Origins: bureaucratic insulation

In the late Sixties Brazil started a large program for scientific and technological development with support from the National Development Bank (Banco Nacional de Desenvolvimen-

to Econômico). For the first time S&T was defined as part of the country's economic development strategy, and resources became available in much larger scale than ever before. Support was provided to research groups deemed competent with a minimum of bureaucratic complications and bypassing both the university administration (for academic groups) and peer review procedures. In hindsight, it is clear that this was a typical case of bureaucratic insulation. There was little coordination between this policy, carried through under the umbrella of the Ministry of Planning, and the economic and industrial policies that took place under other Ministers with different orientations.

Insulation from clientelism, bureaucracy, and short-term economic pressures was indispensable to provide space, time and conditions for scientific and technological research to flourish. Research groups need to be exposed to the larger scientific community, on one hand, and to possibilities of applications, on the other, in order not to get sterilized. Scientific exposure is a constant demand of high quality research groups, and it was possible to provide them with the resources for that. The results are quite impressive. Although small by international standards, the Brazilian scientific and technological community is today the largest in any developing country after India (Schwartzman, 1978 and 1979; Castro, 1985). It has about 20 thousand professional researchers, and about one thousand graduate programs in all fields of knowledge. Extensive fellowship programs allowed thousands of graduate students to go to the best universities in the United States and Europe, and they have usually found places to work upon their return. Quality is uneven, and in the last few years there has been a tendency to divert scarce resources towards politically protected, low quality groups in peripheral universities. However, the best graduate and research institutions are of first quality.

Practical economic results coming from all this investment have been limited, but it would be misleading to at-

tribute it to some kind of ivory tower attitude. Investments have been made in engineering, solid-state physics, tropical medicine, agricultural research and other fields with potential practical usage. However, industrial policy not always favored the utilization and growth of this potential, and scientists, mostly in the technological fields, have always felt bitter about the waste of their energy and intellectual capacity.[4]

Computer science and electronics were among the fields developed under these conditions, and a new, nationalist policy for informatics provided them with an opportunity most other areas did not have.[5] In the early Seventies the Brazilian Navy was operating its ships using English Ferranti computers, and wanted to support a program to develop the country's capability to build its own data-processing equipments. There was a question of national security involved, which became thereafter a central justification for the national computer policy. A pilot project started with Navy's support involving the School of Engineering of the University of São Paulo, which had the competence to work on hardware, and the computer group of the Catholic University of Rio de Janeiro, working on software. The first Brazilian computer, the Patinho Feio (Ugly Duckling), came to light after some time, and two prototypes of an improved version, the G-10, existed in the two universities in early 1976. Cobra, a state-controlled company, was organized in 1975 to produce the G-10 industrially. However, its first option was to assemble computers using Ferranti (English) and Sycor (American) technology, with the understanding that this technology would be fully incorporated by the Brazilians. The Brazilian prototypes were left for research work. A holding company for the computer industry, Digibrás, was also established, as well as a supervising governmental agency, Capre, under the Ministry of Planning. From Capre emerged the initial steps of a nationalistic policy which included a few basic principles: to create a group of 100% nationally owned campanies which could develop their own technology or purchase it from abroad; and only to accept foreign cooperation with arrangements for full

technological disclosure (Adler, forthcoming).

A crucial decision was about which segment of the computer industry Brazilian firms could occupy. The field of large, all purpose mainframes was already taken by IBM, Burroughs and other international companies, and it was out of question. These were the years before the micro-computer revolution, and the decision was to go for the minicomputer industry. In 1976 IBM announced in Brazil a small computer system, called /32, in what was considered a preemptive move to occupy this market's segment. The protacted dispute between IBM and Capre, in the next two years, led to the establishment of an import licensing policy for computer equipments which required, among other things, an association between foreign and Brazilian firms, and growing indexes of nationalization. In late 1977 Capre decided to authorize three Brazilian companies to produce minicomputers with technical assistance agreements with foreign associates, and to the exclusion of IBM, Burroughs and Control Data (Silvia Helena, 1984).

In 1979 the Brazilian government issued an official document setting up the National Policy for Informatics (PNI), wich included the concept of a market reserve for micro and minicomputers for Brazilian companies. It also replaced Capre by the Secretaria Nacional de Informática, SEI, as an agency under the National Security Council. As part of the military intelligence establishment in an authoritarian regime, SEI's power was almost unlimited. It controlled imports, intervened in the creation of new industries, in the organization of data processing centers in companies and universities, and in the granting of federal subsidies to private firms. It could and it did interfere in all branches of government having to do with data processing - which means all of them. This power concentration was perceived as incompatible with the democratic regime that was to start in 1985, and that is why SEI needed a legal mandate, which was granted by Congress at the end of 1984.

3. Growth: corporatism

As stated earlier, the involvement of university departments in the early days of the computer policy provided it with strong ties with the university community, which was very helpful in providing it with technical competence and legitimation. Several among these academics later created their own computer companies, which benefited from the public support and privileges they helped to create. Capre's replacement by SEI generated tensions between this group and many newcomers to the field, some of them coming from the military intelligence and with little knowledge or trust in previous Capre leadership. These tensions were later reduced through better knowledge and change of some actors. This reduction was helped by the fact that most of the military officers involved with PNI had also been trained in the field, and were therefore able to relate intelligently with the academic community and to reinforce an image of competence and efficiency. They came from the more technical sectors or the Brazilian Navy and military educational institutions - the Instituto Militar de Engenharia (IME) in Rio and the Instituto Tecnológico da Aeronáutica (ITA) in São Paulo, and many of them have been trained abroad.[6] A lobby composed of academics, officers, entrepreneurs, students and computer professionals was developed and played a very active role in shaping PNI.

Brazilian firms, which in 1978 produced only 2% of the total installed value, had moved to 19% in 1982. In the micro- and mini class, however, Brazilian firms went from 17% to 80% of the market, which had increased fourfold in these four years. Comparisons between the national and multinational sectors of the computer industry in Brazil show that they have similar sizes, with the multinational sector being more capital intensive, doing less R&D and selling slightly more than the Brazilian one (table 1).

This change occurred not only because of policy deci-

sions, but also thanks to the micro-computer revolution, which opened new opportunities for the Brazilian computer industry. For the first time, it was possible for small firms to assemble computer equipment through the utilization of off-the-shelf components, and the technical competence needed for that was well within the reach of the Brazilian eletronics industry. In 1983 there were about 54 Brazilian computer manufacturers, of which only 11 existed prior to 1974; 25 where created after 1978. These firms started producing "clones" of Sinclair, TRS, and Apple computers, mostly with copied software and operational systems. Peripherals were also produced or assembled in the country - printers, modems, terminals, videos. Adaptations had to be made in software and keyboards for the introduction of Portuguese language and special graphic signs.

There are at least three main types of Brazilian computer manufacturers. First, there are the state-owned corporations. The most important is Cobra, responsible for about 25% of the capital, 16% of the sales and 12% of the manpower of the Brazilian sector. According to international standards, however, it is not a large firm: Cobra's capital for 1983 was only around 15 billion cruzeiros (US$ 15m). Its capital was formed mostly with public funds, and for several years it was troubled with problems of low performance and reluctance of private shareholders to increase their investment levels. It concentrates on the segment of mini and mid-size computers, and is showing signs of improvement in the last few years. A special place is taken by Prólogo S/A, a subsidiary of Indústria de Material Bélico do Brasal (Imbel), the Brazilian state-owned armaments manufacturer. It is a company meant to serve the computer needs of the country's intelligence agencies and the military. It was created in 1980 by a Presidential decree, with a mandate to work in the fields of comunications security and cryptotechnology. Today, according to Jornal do Brasil, Imbel's production ranges from the production of sophisticated military equipments to civilian versions of banking computerization and control, and is moving into the production of robots

Table 1

Comparisons between Brazilian and multinational computer firms (1983)

	national firms	multinational firms
Total sold (US$m)	687	800
total employed	15,734	10,010
total employed in hardware/ sofware development	1,117	121
number of employees with university degrees	3,888	2,810
number of employees with university degrees per 100 million dollars sold	566	351
number of employees with university degrees per 100 million dollars of equipment installed	54	8
million dollars imported	49	179
imports/total sold	7,1%	22,4%

Source: SEI, 1984.

with technology acquired from Asea AB, a Swedish firm. Prólogo is located in Brasília, employs 450 people, and is said to be wholly self-sufficient economically (Jornal do Brasil, February 25, 1985).[8]

Secondly, there are companies formed by individual entrepreneurs coming from the university and other areas. The most quoted example is Scopus in São Paulo, which produces among other things an IBM-PC equivalent, Nexus, and has been compared with Apple for its style (although not, certainly, for its size). Other companies have developed from small electronics and engineering firms.

Finally, and more recently, come the companies linked to the banking system. These companies, quite understandably, are those that are growing more intensively. The best examples are, probably, Itaú Tecnologia, controlled by Itaú Bank, the second largest in the country, and SID Informática, controlled by the Mathias Machine group, 18% of which belongs to Banco Bradesco, the country's largest bank. Itaú, which was already the 4th company in the ranking in terms of capital in 1983, was expected to come first and above Cobra in 1984, with a staff of 1,600. Two other companies to produce electronic components (Itaucomp) and printed circuits (this one in Manaus) were also established by Itaú in 1984. SID sold in 1983 about twelve thousand units of equipment and increased its working staff from 800 to 1,200, and invests 7% of its sales in R&D. Other fast-growing industries include Edisa, with 325 systems sold in 1983 and in 14th place in the ranking; and Dismac, with 2,000 micros sold in 1984 (as against 1,500 in 1983) and about 1 US$ million a year in R&D (O Globo, December 31, 1984).

The rapid growth of the computer field and the press coverage it receives helped to make it one of the most prestigious careers in the country's universities and technical schools. For the unified entrance examinations to the universities in Rio de Janeiro for 1985 there were about 18 candidates for each

place in courses related to computer sciences. The number of candidates for these courses increased by 420% in four years. (Jornal do Brasil, November 23 and 24, 1984). No figures were given for the total number of places available. However, computer sciences (or informatics, in Brazilian terminology) is placed within mathematics, for which there were about 10 thousand candidates for about 1,000 places (The average ratio for all areas was 3.4). The picture for the state of São Paulo is similar.

This demand is related to a movement for the creation of a protected labor market for professionals in the field of computer sciences and data processing. They are already organized in the Associação de Profissionais de Processamento de Dados (APPD) which has been very active in promoting legislation to protect its slice of the labor market. The notion that, to each field of knowledge, should correspond a university degree, a legally protected profession and a slice of the employment market with guaranteed salaries, is part of Brazil's corporatist tradition and is extremely ingrained in the country's culture and legislation. Legally defined professions today include not only Engineering, Law and Medicine, but also Administration, Statistics, Journalism, Psychology, Pharmacy, Biology, Economics, Archeology, Nursery, Social Work, and so forth. There is a bill being examined by Congress creating a Federal Council of Professionals in Eletronic Data Processing. This council, differently from the traditional corporations of medical doctors, lawyers or engineers, would include from terminal operators to system analysts. The new council would control the entrance requirements to jobs performing these activities and see that their working conditions and salary levels are those defined by law. Senator Roberto Campos points out that the use of computers is becoming a personal routine for professionals in all fields, but this law, if approved, would restrict its use for those accredited before that federal council. Since Campos is well-known for his strong opposition to SEI and all its policies, his criticism against this bill is likely to be discounted as just another one of his attacks. The Brazilian

tradition is to approve this type of legislation for all kinds of quasi-professions, and it is not unlikely that, Campos's good arguments notwithstanding, it will happen again.

There is nothing so far in terms of regulation for software, probably because it is so much more difficult to control its imports, and also because of obvious conflicts of interest. Most manufacturers try to make their equipment as compatible as possible with software available in the international market, while software producers would rather have the equipment restricted to national programs, which could be sold for high prices. Some manufacturers have opted for equipment that only works with their own software and vice-versa, leading to expensive products with limited sales. There are plans to adopt UNIX as a common operational system for the Brazilian computer industry, a set of national standards and the introduction of new, advanced technologies for software production. All this, however, is still at the planning stage. Public domain software are non-existent and not planned for; smuggling and illegal copying, however, are widespread.

One could sum up by saying that the field of computer production and operation is being organized in Brazil according to the views and interests of its promoters, producers and professionals, and that this organization follows the usual pattern of corporatist regulation and protection. How long this tendency will hold depend on their capacity to confront three challenges: the changes in the political system, which threatens bureaucratic insulation; the pressures of a growing user's market, which requires quality, services and low prices; and the pressures of international competition, which looms behind the market's pressure in its demand for universalism. Success will depend, in part, on political variables; but it will also depend on the computer industry's capacity to step up its research effort and respond effectively to the internal demands and foreign competition.

4. First challenge: users

The existence of a nationalized industry and a protected labor force in data processing supposes a significant number of users at the receiving end. The computer market in Brazil has been well analyzed by researchers from the Instituto de Economia Industrial in Rio de Janeiro (Tigre, Erber, Piragibe), and we shall only give a brief summary here.

The new computer policy started when computer usage was already well established and a fairly large market for imported equipment existed in many governmental agencies, universities, banks, and companies. In 1976 there were about 5,000 computers in the country, of which 172 were considered "large" or "very large", and 3,300 "mini" (Marques, ABICOMP 84, p. 18). In terms of value, the segment of large equipments ("mid-size" and above) corresponded to about 1,000 million dollars in 1976, as against 144 million dollars for the micro and minis. The total value increased from US$ 1,235m in 1978 to US$ 2,777m in 1982 (Erber, 1985).

In 1981 about 25% of the computers in the country were installed in banks, 13% in service bureaus and the rest scattered among different types of industry and public utilities (SEI, quoted by Erber, 1985). This information ignores, of course, the widely different capacities of the equipments. The Brazilian government is one of the largest computer users in the country. It owns the largest service, Serpro, which handles among other things the income tax data processing. Other large users are Dataprev, the data processing company from the social security system and the IBGE (the census bureau). Besides, there are computer systems in all large state-owned and state-controlled companies, including the public utilities (water, telephone and electricity) and state-owned banks. Most universities have their own computer centers. The country's main airports, banks, and airlines are becoming fully computerized.

Table 2

Characteristics of the Brazilian computer industry, 1983

Number of firms		54	
Total capital:		58	billion cruzeiros/1983
nominal growth 1982/3		141%	
Concentration: largest (COBRA)		25,4%	
of sales 2nd largest		36,5%	
10th largest		78,4%	
% of sales:	microcomputers	28,0%	
	minicomputers	44,1	
	peripherals	18,0	
	other components	9,9	
	total	100%	
Geographical concentration of sales:			
	State of S. Paulo	46,4%	
	State of Rio de Janeiro	26,4	
	Rio Grande do Sul	5,3	
	Brasília	5,2	
	4 regions	83,3%	
Geographical concentration of production:			
	State of S. Paulo	67,8	
	State of Rio de Janeiro	21,4	
	Rio Grande do Sul	8,4	
	Others	2,4	
Type of buyers:			
	Government	9,0%	
	Commerce	16,8	
	Industry	28,2	
	Financial sector	30,0	
	Services	15,6	
	Total	100%	
Employees:			
	primary education	21,2%	
	secondary	50,1	
	higher	28,7	
	Total	100%	(N=15,734)

(cont.)

Table 2 (cont.)

Activities of employees with higher education:	
sales, marketing	19,7%
administration	25,9
production	14,3
technical assistance	12,0
product development	24,7
training	0,3
Expenditures on software:	
in-house	89,5%
software houses	3,0
universities	3,8
foreign supplier	0,9

Source: SEI, 1984.

A market is also emerging for personal computers. From 150 to 200 thousand personal computers were sold in Brazil in the last few years. Most are of the Timex type, costing between one and two hundred dollars; Apple and TRS clones also exist. A survey among users of home-computers in the São Paulo area showed that they are mainly young people (21% less than 19 years, 22% between 19 and 25, only 27% more than 36), and mostly for videogames (33%). Other uses are: data banks and accounting, 31%; word processing, 12%; graphics, 11%; domestic chores, 15%; education, 15%. The average use is 14 hours a week, as against 12 hours in the United States (Veja, December 19, 1984).

It should be noted that these are not necessarily Brazilian-made computers: notwithstanding the government's ban, smuggled micros are fairly easy to buy, and are openly advertised in the newspapers. In fact, the main users of national equipment are not home users or independent professionals, but the financial and commercial sectors (table 2). On the whole, the market is heavily biased towards large, institutional users, and one can say that the micro-computer is still far from becoming an item of mass consumption in Brazil. IBM-PC alikes now appearing are geared towards small and medium-sized firms. Their price is high, they come already with expensive add-ons, and are supposed to be operated by professionals in data processing. Computer shops have not developed very much, and the few computer magazines that exist tend to be loaded with technical jargon, difficult to understand and of little relevance to the non-specialized user. There has been very little done in terms of "user-friendly" software and equipment except what is copied from Apple, and this expression, or its equivalent, is still to appear in the Brazilian computer industry.

For specialists in hardware architecture or software development, a protected market for their activity is considered crucial. For users, either of large mainframes or of personal equipment, what matters is price, reliability, good software

technical assistance and simplicity for the non-specialist, and the Brazilian products and firms are not necessarily the best from this standpoint.[9] On the other hand, internal supply of software and equipment is a matter of concern for governmental agencies not willing to depend on external norms, regulations, and conveniences.

Manufacturers requiring electronic components in their products are another important client and potential source of difficulties. The recent history of Brazil's TV industry is quite fresh in memory. A few years ago, there were several Brazilian industries working with local technologies, located mostly in São Paulo. Now they have been wiped out from the market by firms working out of Manaus, up the Amazon River. Manaus is a Free Zone which provides special favors - mostly fiscal exemptions and import privileges - for manufacturers willing to get established there. Its electronic industry produces video-recorders, TV sets, electronic cameras, calculators, microwave ovens and just about all other consumer goods that rely on imported electronic components. There is now a dispute between SEI and the Manaus authorities for the establishment of computer manufactures in the region. It is a conflict with regional implications, since the national computer industry is mostly located in São Paulo, while the Free Zone is basically a mechanism to attract national and multinational industries to the Amazon area.[10]

Manufacturers of electric and electronic products have their own association, the Associação Brasileira de Indústria Elétrica e Eletrônica (Abinee) which includes Brazilian and foreign firms, and is against any restriction on the imports of electronic components (Brazilian manufacturers working under SEI's protection belong to Abicomp). There is also a very active Sociedade de Usuários de Computadores e Equipamentos Subsidiários (Sucesu), which works as a lobby for users, 70% of which have IBM equipment. Sucesu has about 1,800 firms affiliated, and its own estimate is that it covers 50% of the Brazilian firms with computer installations or services.

In the long run, what will happen with the Brazilian computer policy will depend on its ability to respond reasonably to these demands, and to follow them as they change. If it responds very slowly or inefficiently, the pressure will mount to open the country still further to foreign firms and imported equipment. Sucesu's president, Helio Azevedo, sees a gradient of interests going from scientists to industrialists, computer professionals, users, and the population at large. For him, the weight so far has been on the scientists' and industrialists' side. As the pendulum moves to other extreme, he predicts a "copernican revolution" to happen in the Brazilian computer environment. Much of what will happen will depend on the second challenge PNI has to face, that is, research.

5. Second challenge: research

It is clear to all involved in PNI that it cannot be sustained for long based only on SEI's authority and nationalist ideals, if it cannot keep up with the technological challenges of the field. The pressure for universalism - that is, free market - will grow almost irresistibly, opening the way for foreign technology and companies. Early in 1985 an integrated, three-year research plan in computer sciences was put forward by the Sociedade Brasileira de Computação and the Instituto de Computação of the Centro Tecnológico de Informática. The plan starts with the assertion that the national computer industry, created by professionals coming from universities, is today more advanced technologically than the university system, except perhaps in a few basic areas. Its objective is to go beyond the industry's current capabilities, and open the way for further progress.

The plan provides a brief picture of the current stage of university research in computer sciences (which does not include related fields such as electronics or automation). There are five institutions providing doctoral degrees for 10 persons a year (an average of 2 per institution). The total number of

researchers with doctoral degrees is 108. There are also fifteen institutions providing master's degrees, and a small flux or people being trained abroad and returning to the country. On average, 15 new doctors enter the field each year. The total number of researchers is estimated at 750, 500 of whom work on software. The research plan projects an increase in the total number of doctors to 500 by the end of 1987, as against 300 if the current growth rate is kept. For this, it will be necessary to create new doctoral programs and provide more fellowships for studies abroad. Proportional increases in technical personnel, equipment, library facilities, etc., will also be needed. The total cost for research projects, infrastructure, interchange and follow-up is estimated to be around 40 million dollars in three years. This value is placed in comparison with figures of R&D expenditures in computer science of developed countries: US$ 500m for the "5th generation project" in Japan, 350 million pounds in five years in the United Kingdom, US$ 220m a year for the "Esprit" program in the European Community, US$ 400m for the "Stars" program and US$ 50m a year for the Microelectronics and Computer Technology Corporation, both in the United States. The amount required by the plan is quite small by international standards. However, Brazil would not have the capacity to absorb a much larger sum, given the current small basis of computer research. And even these limited resources may be very difficult to get.

A list of high priority research fields was also drawn. It includes the architecture of digital systems; time-sharing systems; software engineering; data bases; CAD/CAM; artificial intelligence; sign processing and pattern identification; mathematics applied to computing; and computer theory. In all, 65 projects were identified. The research plan can be understood essentially as an aggregation of isolated projects, to which a weak order of priorities was attached. The plan does not refer to research done at the private sector, to the activities of the Centro Tecnológico da Informática, or to the contribution of IBM to university research.

The research effort in the private sector can only be gauged by indirect figures. Brazilian computer firms employ about ten times more people in R&D than the multinational ones (1,177 against 121 in 1983), in spite of being smaller (these figures can be inflated, however, since the concept of research can easily be stretched when a company considers it convenient to do so). Work is done in reverse engineering, software adaptation, and new developments. The number of employees with higher education degrees per US$ 100m sold is almost twice in the Brazilian firms (566 against 351), and more than ten times in terms of R&D (171 vs. 15). There are no figures of R&D expenditures in the private sector. If one assumed that 5% of total sales go to R&D, this would give a figure of US$ 34m a year in R&D in the national computer industry. This figure, however, seems to be too high in terms of the available manpower.

The Centro Tecnológico da Informática was established in 1982 as part of SEI and transformed into the main sponsoring agency for R&D in informatics in the country by the 1984 law. In spite of its wide mandate, it is still a small outfit. It has about 300 people in its staff, working in the outskirts of the city of Campinas, São Paulo, divided among four institutes: automation, computation, instrumentation and microelectronics. It is not a purely research institution: it sells services to the private sector, provides technical assistance and develops joint projects with the universities. As SEI's technical branch, it oversees the fulfillment of nationalization targets of IBM's computer assembly plant nearby and seeks to establish standards and provide certifications for the national computer industry.

The Computing Institute is, among other things, engaged in an ambitious program to develop a "software plant project" which would, according to its leaders, be able to place Brazil at the international frontier in terms of software development. A "software plant" is supposed to be an environment for software production endowed with an array of programming tools and automation mechanisms allowing to go from the typical 3-6 lines an hour of software production to the 10-15 level,

and with better reliability. The Microelectronics Institute is basically concerned with technologies related with microchip production. There is no attempt to compete internationally in terms of large-scale integration. However, the idea is that there is room for the development of custom-oriented ICs, and for some work to be done in all stages of IC production - project elaboration, masks, diffusion, encapsulation and quality control. One of the Instrumentation Institute's projects is to develop mechanisms of digital information processing and display which could be used with widely different sensors, thus providing the scale for instruments production the Brazilian market lacks. The Automation Institute works in the fields of linear and digital automated processes, seeking constant involvement with the industrial sector.

CTI's current budget is about US$ 1m a year, and a projected increase to US$ 3m is still to be approved. Its new mandate requires a much larger budget, but there is no assurance that these resources will be forthcoming. CTI's general director, José Rubens Doria Porto, was appointed as SEI's Secretário by the Tancredo Neves government, which assures a central place for CTI. However, the general policy of budgetary restraint does not favor any dramatic increase of resources for this or any other field in the near future, and, for the first time, SEI will have to dispute resources with other agencies within the Ministry of Science and Technology.

IBM is a relatively new, but potentially heavy newcomer to R&D support in Brazil. In the past, it provided the Catholic University of Rio de Janeiro with hardware and assistance, helping it to become the first and probably the best computer science department in the country. More recently, however, it did not match CDC's offer for a new mainframe to the Catholic University, and lost that special relationship. Now, according to an IBM spokesman, the company expects to provide equipment and support to 18 among the best universities and research centers in Brazil during the next four years, spending

about 40 million dollars in equipment, software, technical assistance and fellowships. The beneficiaries include the School of Engineering of the State University of São Paulo, the Laboratório de Computação Científica of the National Research Council and the Federal Universities of Rio de Janeiro and Pernambuco. Other support activities from IBM include about 20 fellowships for graduate students in the country and three for post-graduate studies in IBM laboratories in the U.S. every year; a Software Institute for teaching in software engineering; a Latin American institute for system analysis (LASTRI) which provide courses for IBM and non-IBM personnel; and a Scientific Center in Brasília with about 10 researchers at the doctoral level, working in applications in the fields of energy, administration, economics and health, in association with Embrapa (agricultural research), IPE (space research) and other institutions. IBM provides also technical assistance to Brazilian suppliers to its factory in Campinas, which exports around US$ 200m a year in equipment to many countries.[11]

The Brazilian research effort is still very limited in size, and will have to increase quite considerably if the ambitions of PNI are to be met. Besides, tensions among these different research programs and support lines are likely to happen. There is a dispute between CTI and several university departments about their respective roles in R&D. For some departments, CTI is diverting resources from the universities, and occupying fields which are not adequate for a governmental research outfit. For CTI, university research institutes should not provide services to industry, a role more properly performed by CTI. CTI defines itself as a priviledged interface between the universities and industry, a role resented by some university departments.

The growing presence of IBM also generates tensions. The research plan organized by CTI and SBC contemplates only the incorporation of nationally produced hardware in the universities, and it is clear that SEI does not appreciate the

spreading of "IBM culture" and equipment. On the other hand, university departments using computers as research and teaching tools are quite happy to receive this support. It seems obvious that IBM seeks to stimulate applications of computer equipment in its own terms, therefore making itself indispensable. Changes or improvements of computer plants in the universities have to receive SEI's approval, which means that IBM's activities are closely supervised and attrictions are bound to occur. At the same time, there will be no match for IBM if she really goes ahead with its plans to equip the universities at no cost.

6. Third challenge: politics

Whether SEI will be able to keep its authority, and whether research money will be forthcoming to CTI and the universities, it all depends on politics. Bureaucratic insulation is being challenged not only by external competition, pressures from the users and the speed of technological inovations, but also by the changing political climate which makes bureaucratic insulation much more difficult to keep today than in the near past.

The Bill institutionalizing PNI was send to Congress by the Brazilian government in June, 1984.[12] The text, among other things, defined the general objectives of the new policy, established a National Council for Informatics and Automation (Conin) and defined the scope and authority of the Secretaria Especial de Informática (SEI). SEI was empowered to examine in advance all import requests for goods and services related to informatics for 8 years. The law also authorized the creation of a research agency, the Fundação Centro Tecnológico para a Informática - CTI and a special fund for informatics and automation.

Many things changed between the first text and the version approved by Congress, which, throughout 1984, acquired

increasing autonomy from the Executive. Originally, Conin and SEI were to remain under the National Security Council. In the final version, Conin came directly under the President, side by side with the Councils for Social and Economic Development, the National Information Service (SNI), the Armed Forces High Command (EMFA), and the National Security Council itself (in comparison, the National Research Council remained within the Ministry of Planning, in a much lower position). More significantly, Conin and SEI were taken away from military jurisdiction. Now the Secretaria de Informática (SEI) was to be controlled by a collegiate body, and placed under a non-specified Minister. In the new government, this is the newly created Ministry of Science and Technology.

Further changes were introduced by the Executive, which enacted the bill with a few vetoes on October 29, 1984. On December 27 the President issued a "decree-law"[13] changing some items of the original text and three decrees regulating the law's implementation. The vetoes killed two ammendments made by Congress dealing with protection of citizen's rights to privacy and employment, as they could be affected by the new technologies. Also, it eliminated a tax which would provide the newly created fund for informatics with sizeable resources for research and development. Finally, they left open the number of members of Conin, a decision which was perceived as a door to give it a majority of military officers. The decree-law changed the original definition of "national companies" to include those with open capital but with 70% of it (or 2/3 of the voting shares) in hands of Brazilian residents, public corporations or companies. It also subjected any change of the control in these companies to governmental approval. The aim was to make room for banks and other companies with publicly traded stocks; one of its consequences is, of course, to open the door for non-controling foreign capital.

The first decree has an extremely detailed definition of Conin's attributions. Its mandate runs along 32 items, from the elaboration of a National Plan for Informatics and Automa-

tion to the establishment of technical norms, control of international data transfers, evaluation of teaching programs for professional training, creation of research centers in the country and abroad, aproval of projects of technological transfer and of capital increases in companies. It has also a say in matters of import and export policies.

All this wide-range power is diluted, however, by the way the Council is to be organized and run. Of its 22 members, 14 are Ministers, 8 are chosen from lists presented by interest groups related with informatics (users' associations, computer companies, professional and scientific societies, etc.). Even the Bar Association was contemplated, presumably for its concern with the citizen's individual rights. This format not only guarantees the government's control over Conin, but also that its meetings will be made up mostly by the Ministers' deputies with usually no knowledge of the subjects under discussion and no autonomous decision power. Besides, the Council is supposed to meet only once every two months, and the members are not allowed to request time to examine the documents under discussion (article 5). Still more significantly, two presidential vetoes (to article 7,III and 8,V) limited Conin's power to make decisions, making it a predominantly normative and advisory body and leaving all practical power to SEI. With this structure, Conin is bound to become essentially a legitimizing and rubber-stamp institution.

According to the second decree, SEI is supposed to be subordinated to Conin and act as its executive agency. All Conin's decisions are to be previously prepared by SEI; besides, it keeps its role of analyzing and approving projects of development and production of computer goods and a previous say on all imports related with the computer industry for 8 years from the approval of the law in 1984. SEI runs a special Fundo para Atividades de Informática (FAI), has financial and administrative autonomy and is led by a powerful Secretário with supporting staff and sub-secretaries. The Secretário is appointed by the President upon recommendation of the Minister in charge

of Conin.

The last decree approves the by-laws of the Fundação Centro Tecnológico de Informática which was created by the law as an outgrowth of the Centro Tecnológico de Informática. The Fundação is to be a state-owned institution that runs according to private law with wide autonomy to hire and dismiss personnel, set salaries and manage its own resources. CTI is entitled, among other things, to create new entities in Brazil or abroad, sign contracts with universities and research centers, and take loans in the country or abroad. It has its own institutes and a complex administrative structure run by a president nominated by the President of the Republic. It does not report to SEI's secretary, but directly to Conin and to the Minister in charge of informatics.

In many respects, these decrees are being interpreted by observers as a last-minute attempt of the Figueiredo government to reverse the intention behind the changes introduced by the Congress, aimed at reducing SEI's power by making it a mere executive agency of Conin, with limited policy-making authority. According to this view, the support SEI received from the Democratic Alliance (the political coalition which elected Tancredo Neves) cannot be taken as an unqualified endorsement, but resulted from a political understanding between Neves and a more militant group in his own party which was reluctant to agree with his election by an electoral college. Conin was meant to be transformed into a meeting ground for different interest groups (including the different ministries in a coalition government), which would reduce what was perceived as SEI's one-sided commitment with national producers of computing equipment.

It is still too early to say what will happen in the new government. The presidential vetoes can be reversed by Congress, and the new government can change the decrees. The nomination of Doria Porto as SEI's Secretary means that there will be continuity with PNI's general philosophy. At the same time,

SEI's placement under the newly created Ministry of Science and Technology reduces its power and political access which is compounded by the political weakness of the new Ministry, due to problems related with the illness and final death of Tancredo Neves. This Ministry is already flooded with pressures for research money coming from all sectors, and clientelistic demands are bound to increase, while money is expected to remain short for everybody. External pressures are also likely to increase. Brazil will have to negotiate its debt with foreign creditors, who in the past have used the opportunity to press against the computer market protection, and can be expected to do it again.

7. Prospects: the birth of an industry or a "technological window"?

The official and more commonly held justification of PNI is that this is a necessary stage in the beginning of any self-sustained industrial development. According to this reasoning, national industries should be protected for some time from external, more mature competition, while they gather strength. The Brazilian history of import substitution in the industrial sector is said to confirm this. There is certainly a learning process expressed by the increasing sophistication, nationalization and low cost of the computer equipment being produced by national companies. It should be noted, however, that this is the first time in the country's history that a segment of the private industry is closed to foreign companies, either alone or in association with Brazilian firms. All previous experiences of market protection were aimed at Brazilian-made products (such as cars, appliances, and other electric products), not companies, except in state-controlled areas such as oil or telecomunications. In this sense, the current policy for computers is not comparable with previous experiences.

It is possible to argue, moreover, that what appears to be the initital stage of an emerging national industry is

in fact just a "technological window" opened by the microcomputer revolution of the last few years, which is already coming to an end. The Brazilian computer industry relies on integrated circuits which are imported or produced locally by subsidiaries of multinational corporations. So far, it has been possible to produce reasonable clones of the Apple, TRS and even IBM PCs, through reverse engineering and the use of components available in the international market. Prices of Brazilian microcomputers are falling rapidly for 8-bit models, coming close to the international levels (this is not true, however, either for the IBM-PC compatibles or for peripherals such as monitors, disc-drives and printers). If, however, computers such as the Apple's Macintosh, based on dedicated and proprietary chips, represent the trend, the same pattern of imitation is considered impossible to maintain.

But who needs Macintosh? It has been argued that the Brazilian computer industry should not seek to emulate the American or Japanese patterns, but address itself to the country's actual needs. New products such as Macintosh respond to the conditions of competition of the American market, and not necessarily to an existing demand or need. Seen from this light, the technological gap, although impossible to overcome, is not necessarily a reason to condemn the current policy of national self-reliance. There is, of course, an alternative reasoning, which is the notion that Macintosh represents the first major step of the computer industry into the mass consumption market, because of the direct access it provides to the non-professional user. If this is true, the consequences will be serious for a country which decides to stay away from this type of transformation.

What makes this question more complicated is, of course, how to define what the "national needs" are. In some areas, such as telecomunications, the "national need" has been defined as the interlinkage of all regions of the country, and of the country with the world, through the most effective means, from telephones to satellites. This demand comes in part from

large users of communication facilities, such as the TV networks, and in part from the drive of state-owned corporations working in the field, like Embratel. In this area, there is a clear tendency to utilize only state-of-the-art technologies, and an obvious impatience with the limitations brought about by the current policy.

In other fields, such as banking, the need seems to be defined mostly by competition between firms. Brazil does not "need" 24-hour automatic tellers, or on-line services in the banks. In other countries, automatization of the banking system is essentially a labor-saving device. Given the low salaries paid in Brazil, and the high costs of the new technologies and its instalation, it is doubtful that the motivation in Brazil is the same. Although it is clear that with the new technology changes in this labor force are bound to occur, with new skills becoming more important and others turning obsolete, this seems to be a consequence, rather than the reason for the changes.[14] Besides competition, the bank's entrance in the computer industry represents for them an important and profitable diversification.

For SEI's new secretary, the current policy is irreversible, in spite of eventual adjustments. There are already too many interests involved, and great awareness of its need. He believes that the notion that there is an increasing technological gap between Brazil and other countries is mostly a myth. He gives as an example the fact that the basic architecture and operational systems of large mainframes have not changed for many years, in spite of the development in chip integration. This stability is explained by the amount of capital and knowledge invested in established technologies which would be too costly to replace.[15] Since Brazil did not make this previous investments, it could jump stages and work at the frontier. Brazil cannot compete in the market of highly integrated, mass produced chips, and could not work with too specialized products for small markets. Because of the country's size, however, there should be places for products of in-

termediate scale, for which there would be special comparative advantages. To find these advantages, or the "niches" the national companies could occupy, should be the basis of the whole policy. Examples would be "software plant project", the development of pace-makers for carriers of Chagas disease and a whole array of custom-made chips for medium-size markets, where large economies of scale are not feasible.

This policy can have its drawbacks. It excludes the two extremes of the computer market, the one dominated by mainframes and the large public which will eventually move into the massive utilization of microcomputers. For the former, access to international technology is open, and will probably continue to be so. Arrangements can also be made with local universities and research institutes to meet their needs. For the latter, however, the situation is more difficult. The problem is not just the availability and price of microcomputers, but the whole development of a user-oriented computer industry which is expanding so quickly in the advanced countries, but is badly lagging behind in Brazil. As this industry reaches the educational systems and the daily activities of small firms and independent professionals, there will be an increasing gap, not just towards foreign technology, but towards the whole computer culture that is emerging in the developed countries.

It is clear that the people responsible for PNI are not simple-minded nationalists determined to "reinvent the wheel". They may even talk, eventually, about "liberation technology" (after the famous Liberation Theology preached by many sectors of the Latin American Church) but are in fact looking for the special niches and opportunities the Brazilian computer industry and society can hope to occupy. The market reserve for microcomputers is only part of the whole strategy, which includes also a wide range of associations between Brazilian and foreign companies willing to share their technologies with its local counterparts. They were able to bring the question of computers and their utilization to the forefront, to develop national

competence and stimulate the large multinational corporations to behave in a way they would probably not have done otherwise. Because of this policy, and because there are now sophisticated counterparts in Brazil, they are willing to talk about joint ventures, technological transfer, open technologies. Even IBM, which does not accept joint ventures, is competing for space in more positive (or at least more subtle) ways, through support to universities and technical assistance to local suppliers.

In all probability, PNI is not just a "window" opened with the Sinclair and Apple clones, to be closed with Macintosh. Given enough time and resources, Brazil will be able to build enough competence to attend to significant parts of its internal market, to find products it can export, to protect its local industry from foreign dumping and to reach reasonable standards of coexistence with international firms and international trends. There is, however, a race with time. Bureaucratic insu lation can easely get sour: isolation can breed incompetence. And political clientelism, in a context of economic recession, can rapidly dismantle R&D capabilities built up through many years. Brazil is an open society, its integration with the international economy and culture is irreversible, and there will be increasing pressures from users not to be kept behind by inferior technologies, bad service, customs controls and industrial privileges. These pressures will certainly be stimulated by foreign competitors, all too willing to demonstrate their presumed superiority and offer their services.

In order not to lose this race, investments in R&D and computer education in Brazil will have to increase quite significantly, a bigger effort to look at the computer industry from the user's point of view will have to be made, and a sophisticated view of the niches the Brazilian industries can occupy,in this complex and increasingly internationalized sector, will have to be kept at all times. It is possible to predict that, when the fad of computer games is over (as it is already in the United States and Europe) the future of the microcomputer sector will depend on the Brazilian capacity to com-

pete with the applications and "friendliness" which is being developed elsewhere. An important switch will have to be made from the producer's to the individual user's point of view. a change which is not nearly in sight. At the other extreme, Brazil is likely to continue to import large, sophisticated equipment for a long time. But, as the computer technology develops, the distinctions between "mini", "mid-size" and large computers tend to get blurred, and associations between Brazilian and foreign companies willing to share their technology will tend to increase. One can expect that, given appropriate support, these joint ventures will eventually branch out to both extremes of the computer industry, without necessarily destroying the purely national sector which is being developed under the umbrella of market protection.

Notes

*This paper benefited from conversations held with people at the Centro Tecnológico de Informática, Sucesu, IBM do Brasil, and other knowledgeable participants of the current developments in the computer field in Brazil. None of them are responsible for my understanding of what they said. I am grateful to Professor Peter H. Smith, Department of Political Science, M.I.T., for the invitation to write this text and present it at the Seminar. I am also indebted to Alexandre Barros, Claudio Moura Castro, and João Batista Araujo e Oliveira for criticizing a first version of this paper.

[1]"Informatics" (as in French, "informatique") is the standard word utilized in Brazil to cover the whole field of computing, microelectronics, automation, etc.

[2]It was not by chance that Lobato was from the state of São Paulo, the country's more dynamic economic center, while his opponents at the National Department of Mineral Production were mostly from Minas Gerais, a state with a weak private economy but a well reputed, and quite traditional, School of Mines. See Schwartzman and Castro, 1985, and Carvalho, 1979.

[3]I will take for granted, throughout this text, that it is preferable to have the whole computer industry's productive cycle in the country than to rely only on imported equipment based on unknown "black boxes". There are enough economic, political and cultural arguments for this preference which need not be repeated here. The problems to be analyzed are not related to its desirability, but to its feasibility and costs.

[4]The example of COPPE, the graduate engineering program of the Federal University of Rio de Janeiro is striking. Its ambition was to cover the full range of modern technologies, including nuclear, chemical, electronic and naval engineering. However successful it has been in comparison with other engineering schools in Latin America, it soon became clear to COPPE leaders that they had become much more competent than what the country's industry could absorb. Cf. Nunes, Silva and Schwartzman, 1982. At the opposite end, agricultural researchers like to emphasize the economic returns of their work, in terms of yields and profits generated by new technologies.

[5]The involvement of the scientific community with the computer policy should be seen in contrast with its alienation towards the Brazilian nuclear program, which is exactly the opposite to what happened in Argentina. These parallels are made explicit by Adler, 1985.

[6] ITA's presence is particularly significant. It was organized in the Forties as an engineering school run by the Brazilian Air Force and became the country's leading engineering school, open to civilians through nationwide entrance examinations. Around ITA developed the São José dos Campos industrial and technological complex, where the country's most sophisticated technological institutions are located, including the Instituto de Pesquisas Espaciais, Embraer and many private companies. ITA's alunni also helped to build in the University of Campinas one of the best physics department in the country.

[7] Cobra's capital was formed with resources from state companies - Serpro, Banco do Brazil, Caixa Econômica Federal, BNDE and Digibrás (56%), a pool of national private banks (39%), and EE Equipamentos Eletrônicos (Brazilian) and Ferranti (English) with the last 5%. (Cf. Tigre, 1982, p. 114-5). A full account of Cobra's history is given in a forthcoming book by R. Ramamurti (1985).

[8] Working under secrecy, Prólogo is an extreme case of bureaucratic insulation, and there is no way to assess whether its claims of efficiency and self-sufficiency are correct. Based on experiences of other secretive operations in Brazil, one would usually expect the opposite (I am grateful to Alexandre Barros to calling attention to this point).

[9] In fact, complaints about the lack of technical assistance and support are widespread among users of Brazilian equipment, which explains the preference enjoyed among large users for IBM.

[10] The establishment of microcomputer manufacturers in Manaus can force all other firms to move there to remain competitive. The free trade zone authority, Suframa, is not committed to policies of technological transfer, and this can press the national industries there to give preference to imported, rather than to nationally produced components, exactly as it happened with the TV industry and sound equipment industries.

[11] The participation of Brazilian employees and suppliers in its Campinas factory is a big item of IBM institutional publicity in Brazil. However, there is no publicity about its support for R&D, for cautionary or some other unknown reason.

[12] According to the country's authoritarian constitution still in place, a bill coming from the Executive has to be voted by Congress within a pre-defined period, or it is automatically enacted.

[13] "Decree laws", another instrument of authoritarian power. Through them, the President can legislate by decree and "ad referendum" from Congress, which has 90 days and needs a ma-

jority of 2/3 to reject them. The current Brazilian government has decided not to make use of Decree Laws before they are banned by the country's future constitution, as it is expected.

[14] One explanation for the rapid entrance of Brazilian banks into automation are the profits derived from the speed of electronic funds transfers, which allow the banks to remain longer with the costumer's resources and maximize their allocation. Another consequence of the current trend is the concentration of Brazil's banking system, with the elimination of those which cannot keep up with the automation race.

[15] In that sense, and contrary to the common understanding, microelectronics and computing would be "mature technologies", like steel production or pharmaceutics before the introduction of genetics engineering.

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VARIETIES OF NATIONALISM:
THE POLITICS OF THE BRAZILIAN COMPUTER INDUSTRY*

Peter Evans

As Professor Simon Schwartzman has made clear, while technological and technical factors are of course important in the evolution of the Brazilian computer industry, politics have been central. Without the convergence of a variety of nationalist policies or a variety of nationalisms, there would be no indigenous computer industry in Brazil. Therefore, in order to understand the Brazilian computer industry, we must analyze these nationalist politics in some detail.

This is not to say that nationalist politics are the only kind of politics involved in the computer industry. Obviously, as it was brought out in the discussion of Professor Schwartzman's paper, there are other political questions that are equally important, and, some might argue in the long run, even more important. Fernando Henrique Cardoso and the P.M.D.B. divide computer politics into the national question on the one hand and the democratic question on the other. The democratic question has to do with the implications of new informatics technology for the decentralization or the centralization of the control of information: Will information or information processing be an instrument of liberation or oppression?

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* Talk presented at the M.I.T. Symposium on "The Computer Question in Brazil," Cambridge, Mass., April 16, 1985.

There is also of course the distributional politics of computers, whether robotics and automation will result in the marginalization of an increasing proportion of the Brazilian labor force. I think these questions are very important, but I am not going to discuss them here. I mention them to alert you to the fact that they are left out of my presentation. Instead, I will concentrate on the "national question."

In order to understand either the current policy or to speculate as to the future evolution of informatics in Brazil, we have to examine the nature of nationalism as applied to informatics. I think that the special nature of nationalism in informatics is nicely summarized in Article 12 of the new law that was passed in October 1984. Article 12 defines a national firm in terms of three kinds of controls: control of decision making, that is to say that the decision-making centers of the firm are supposed to be located in Brazil; control of capital, or who owns the equity, which is of course the traditional definition of a national firm; and control of technology, that is to say, to be a national firm under the new national informatics law, the firm must in theory have the capacity to generate its own technology. Now, this is a relatively unusual definition of what constitutes a national firm, both traditionally in terms of Brazilian history as well as internationally. It brings out, I think, the rather special nature of nationalism as it has been applied to the informatics sector.

So let us step back for a minute and look at other varieties of nationalism, some of which are involved in the informatics sector, some of which have been important in the past, and others which I think are going to become more important in the future.

A policy that is "economically nationalist" can take a variety of forms. One we might call "security nationalism," that is to say, putting under national control those industries which have to do with national defense or which are considered central to national security. This is a nationalism that is very sectorially restricted, although it might be quite embracing in terms of the expansiveness of the control desired within those sectors. Security nationalism was obviously very important in the origins of the informatics policy. The fact that informatics was defined by key groups within the military as an issue of national security was essential to the origin of the industry.

More traditional in Brazilian history is what we might call a "developmental nationalism," that is to say, a nationalism which defines the national interest in terms of the geographic location of the process of production itself. The auto industry is a prime example of this developmental nationalism in action. The implantation of the auto industry was considered a victory for nationalism in its era because it internalized value added within Brazil and it moved the location of production within Brazil's geographic boundaries. But this kind of nationalism did not put the production under the control of the capital, to say nothing of involving the requirement of indigenously developed technology. It is important to remember then that one can have a nationalist policy which involves simply locating production geographically within Brazil. It is therefore possible to redefine nationalism in a way quite different from the way in which it has been defined in the informatics industry, as involving, for example, the implantation of wholly owned TNC subsidiaries in Brazil.

Assuming that nationalism involves local capital control, we have what we might call "pecuniary nationalism," that is to say, a nationalism which sees the national interest as lying primarily in the allocation of a certain proportion of the flow of capital generated by a productive industry to national capital or to the local industrial bourgeoisie.

If we look at other examples of nationalism in Brazil, we can find pecuniary nationalism, that is to say, a nationalism which defines the nationalization of the industry in terms of the flow of capital in addition to the geographic location of production. Indeed, we can find an example quite close to informatics. Brazil has embarked on a nationalist policy in telecommunications, but that nationalist policy involves the requirement that foreign capital share capital flows and share equity participation with local capital. It does not generally involve the requirement that those firms use or develop indigenously their own technology (though of course indigenously developed technology has emerged in some cases). Nationalism in telecommunications has been defined in terms of pecuniary national interests in addition to some degree of security interests, and in addition clearly to the sort of developmental nationalist interests of geographic location. But it has not been defined in terms of what characterizes most uniquely the informatics sector, that is, a kind of "technological nationalism," which says that the national interest is served insofar as indigenous capacity to develop technology is generated by the policy.

Why should it be the case that technological nationalism emerged in the informatics sector? I would argue that that association between

informatics and technological nationalism has to do not simply with the economic or technological features of the industry, but with the particular kinds of alliances that lie behind the current policy. As Professor Schwartzman has pointed out, these alliances were developed primarily within the state apparatus. People like Ricardo Saur, who has been labeled by one North American student of the informatics industry as an "ideological guerilla" operating within the state apparatus, were extremely important in creating this alliance. They were able to create a sense of shared interest with powerful figures or powerful interests within the military and the security apparatus at various times. But, this was not principally an alliance of capitalists or people with pecuniary interests in the computer industry; rather it was an alliance of technologists, or technicos, and people within the state apparatus. Understanding that social structural base of the original alliance is to understand the reason for the way in which nationalism has been defined in the industry. It is because of that peculiar base and the special definition of nationalism that Brazilian policy has come to be viewed as a very special example of economic nationalism and as a possible exemplar for other countries.

At the same time, it is very important to point out, as Professor Schwartzman's talk indicates, that while this policy is unquestionably an economically nationalist policy, and while the economic nationalism that is embodied in it is essential to the policy and essential in understanding the development of the Brazilian industry, it is at the same time a highly international policy in practice.

Brazil's computer policy is not only internationalist in that it presumes that local producers of small computers will continue to rely on imported microprocessors and that it allows 100 percent foreign-owned subsidiaries to dominate the mainframe market. It is also internationalist in that it has fostered some very interesting joint ventures and licensing agreements between foreign and local companies producing "mini" computers. Outstanding among these is perhaps the licensing of the DEC Vax-11, a uniquely successful example of bargaining in an internationalist vein made possible by a nationalist policy. Brazilian computer policy is, in short, a very complex blend of nationalist and internationalist elements and its success depends on that.

Having recognized its internationalist side, it is still worthwhile to probe the peculiar kinds of nationalism that are involved in Brazil's informatics policy. First, it is important to realize that once the policy emerged, its success depended on the construction of new alliances quite different from those which originally lay behind it. The possibility of those new alliances was generated in part by the policy itself. Most obviously, the policy created the possibility of national capital in computers. National capital then became a new ally, a new actor in the definition in the nationalism that lay behind the informatics policy. In part because of this new actor and in part because of the activity of the earlier actors -- above all technicos, the nationalist policy that was generated in the mid-70s was also able to enlist yet another kind of national ally -- people who were basically political nationalists in the traditional anti-imperialist sense or in the traditional more global national interest sense. Of principal

importance here are politicians like Christina Carvates and Severo Gomes, who had a general ideological interest in nationalism but were not particularly involved in the sector itself. The enlistment of such people was essential to the passage of the 1984 law. In other words, it was an expansion of that nationalist alliance from something that existed inside the state apparatus, and, in particular, in an insulated part of the state apparatus, to a broader sort of alliance that made possible the sustenance of the policy.

Until 1984, the expansion of that alliance did not, however, involve fundamental redefinitions of the earlier project that had been essentially defined within the state apparatus, principally by technicos, but also by people involved on the basis of security interests. However, if we look at the Brazilian computer industry in 1984 and try to predict what kind of nationalism is likely for the future, I would argue that we must look at what kinds of capital are involved in the industry and at the interests of that capital and ask how is that capital likely to choose among the variety of nationalisms that are available.

First of all, where is an important segment of capital involved in the industry which flows directly out of the same kinds of interests that originated the industry, firms whose position in the market is based primarily on their indigenous technological prowess. These are firms who came into the industry with almost no financial capital but whose founders had technological abilities and were able to transform these skills into important positions within the industry.

One of the outstanding examples of that kind of firm is a firm called "Scopus," whose founders came out of the University of São Paulo. In Rio, an example is EBC, which is again a firm essentially created by university people operating with very small amounts of money at least in the beginning. Both firms depend on their technological prowess for their survival and depend on the exclusion of competing foreign technology from the Brazilian market for the maintenance of their current positions. Scopus and EBC would be in trouble if it were possible indiscriminately to license foreign technology. Foreign partners are looking for local economic strength; by definition they do not need the kind of technological prowess that is located in those firms since technology is what they are licensing. Therefore, it is those firms that have been the strongest lobby behind the inclusion of local capacity to generate technology in the definition of national capital in the new informatics law. Edson Fregni, who is the president of ABICOMP, the Brazilian Computer Association, is also the president of Scopus, and in general this kind of capital has been tremendously important in sustaining a definition of nationalism in informatics that includes "technological nationalism."

Another important kind of capital in the industry, again at the lower end of the market, firms making TRS-80 or Sinclair emulations, firms like Prologica and Microdigital, also have a powerful interest in the exclusion of indiscriminate licensing of foreign technology because their success depends on the fact that the foreign originators of this technology can neither enter the market themselves nor freely choose local allies to represent them. These firms are different from the

previous kind of firms in the degree to which they generate technology locally but they also have a powerful interest in the maintenance of a technological definition of nationalism.

As computers have become more clearly a growth industry, the earlier more technically oriented participants have been complemented by a different kind of firm, companies whose principal "comparative advantage" lies in their financial strength rather than their technical know-how. These companies are much more likely to be able to benefit from a pecuniary definition of nationalism and might even benefit from a relaxing of the emphasis on "technological nationalism." The purest example of capital that became involved in the industry as financial capital, Brasilinvest, has unfortunately collapsed for reasons related to its role in informatics. But there are other participants, which although they may have to varying degrees interest in local technology, must count financial strength as their principal basis for entry. Brazil's two biggest banks, Bradesco and Itaú, are prime examples. These big banks would be attractive partners for high-technology TNCs even in the absence of restrictions on the inflow of foreign technology. Such restrictions may provide potentially useful bargaining chips in negotiations with TNCs even for these firms, but they can afford to be much more flexible than technologically oriented capital.

The split between "technological capital" and "financial capital" seemed clear in the spring of 1984 when technological capital strongly opposed the licensing of foreign "super-mini" technology, arguing that Brazilian firms would soon be able to develop "super-micros" to fill mid-range user needs. At least some members of this group saw the

licensing as an abandonment of technological nationalism. On the other hand, both of the major banks were involved in proposals for licensing foreign technology. (Bradesco, for example, was a major participant in the group that licensed the DEC Vax-11.) Technological capital lost this round and licensing was allowed. Whether this is a harbinger for the future is unclear, but what is clear is that as a wider range of private capital becomes involved in the industry, there is bound to be more diversity in the ways in which that capital defines its interests.

The other actors that have become increasingly important in the industry, which leads again to a strong pressure for the redefinition of nationalism, are users. Computer users have different interests than producers. So far, the sort of blend of nationalism and internationalism that is embodied in the current policy has been sufficient to avoid user pressure that might undercut technological nationalism. But, it is interesting to note that the traditional names in Brazilian industrial capital -- Votorantim, Villares, Bardella, etc. -- are not directly involved in the industry as producers. Instead, they relate to it as users. So far it appears that their interest in obtaining foreign technology like industrial process controls has been served by the internationalist side of the policy. It has been possible to create some joint ventures in that area and it has been possible to import the technology that they need.

But, as the Brazilian policy succeeds in generating more use of computers, user interests will become still more important. Insofar as they do, a definition of nationalism which stresses the efficiency of the national economy rather than providing local capital with the possibility

of capital flows from the production of computers or maximizing the generation of indigenous technology becomes more possible. In short, an "economic efficiency" definition of nationalism may emerge out of the users and begin to contest the current technological definition.

What I am arguing overall is that to understand the definition of nationalism one has to look at the particular alliance that lies behind the construction of the policy. But, the very success of the policy itself generates a different set of social structures, generates new actors with different interests. It is, therefore, highly unlikely that the policy will maintain its present form, simply because the social-structural underpinnings of the nationalism that created it have changed. If one looks at the changes in those social-structural underpinnings, the prediction must be that there will be a move toward an increasing amount of alliance between national capital, defined in terms of equity ownership, and transnational capital.

Already last year, there were strong rumors that Itaú and IBM had been negotiating a possible joint venture. This of course illustrates the other thing that changes when this policy succeeds. The attitudes of transnational capital tend to move in response to the existence of that nationalism, which contributes to the likelihood of alliances. In addition to the possibility of joint ventures between existing participants like IBM and local capital in the industry, there are also of course possibilities of bringing new interests into the industry, people who are not as deeply involved in the industrialization of Brazil as they could be, like Fujitsu or AT&T. The construction of increasing transnational alliances would both provide new opportunities for

pecuniarily defined nationalism for strong finance capital groups within Brazil and also would respond to the interests of users by increasing the number of participants in the industry.

Even if alliances with transnational capital increase, however, one should not see this as a victory of dependence, a return to the status quo, or a sign that the Brazilian policy was a "flash in the pan." Whatever new kinds of internationalism might emerge within the Brazilian industry, they will never replicate the situation which would have occurred if IBM and other TNCs had been allowed to develop the small computer market by themselves. Whatever new sets of policy lines emerge will start from a very different place than they would have started from in 1977. Again, precisely because of the social structures created by the old policy, any new internationalism will confront a very different situation and will therefore have a very different character than it would have had in the absence of these previous policies. The heritage of technological nationalism has changed the situation even if it becomes redefined, the new situation will never involve the degree of transnational domination that might have occurred in the absence of the previous policy.

PERFORMANCE AND PERSPECTIVES OF THE BRAZILIAN COMPUTER INDUSTRY*/

Paulo Bastos Tigre **

The promotion of an indigenous computer industry in Brazil depended on the imposition of protectionist barriers against imports and local manufacturing by multinational firms. This policy was defended on the grounds that infant industries could not compete directly with established manufacturers. Policy makers argued that the costs of protection would be compensated in the long run, if firms acquire technical capabilities to design, develop and manufacture up-dated products at competitive prices.

It has been argued, however, that computer users in Brazil are paying too much for their equipment. One of the main arguments against the policy is that computers are typically an input into other industries so that protection of locally manufactured equipment could impose a tax in the form of higher input prices on the rest of the industrial sector.

The aim of this paper is to assess the evolution of the price competitiveness of locally manufactured microcomputers, both Brazilian-owned and subsidiaries of multinational firms, and to compare them to American prices. It intends to provide empirical evidence towards a better understanding of the technology learning process in the computer industry.

In Brazil there are more than 30 microcomputer manufacturers.

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* Paper prepared for the M.I.T. Symposium on "The Computer Question in Brazil," Cambridge, Mass., April 16, 1985. Based on P.B. Tigre and L. Perine, "Competitividade dos Computadores Nacionais," IEI/UFRJ, November 1984.

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Although some firms like Cobra, Itautec and SID designed original products, most manufacturers have reverse-engineered the world best-seller microcomputers. This paper analyses the price evolution and competitiveness of Brazilian clones of the Apple II and TRS-80 and the HP-85 manufactured in Brazil by a subsidiary of the Hewlett-Packard Corp.

The microcomputer Apple II is considered one of the most successful products in the history of computers. Worldwide sales climbed from 2,500 units in 1977 to 1,000,000 in 1984. It was designed under a conception of open architecture both in hardware and software, utilizing the Motorola 6502 microchip and the DOS operational system. Consequently, the Apple II was widely copied by firms from various countries. Some of the so-called Apple-clones such as the ACE micro of Franklin Computers are considered to be improvements on the original equipment.

Another strategy pursued mainly by East Asian manufacturers is to be price-competitive rather than to compete in quality and performance. Apple-clones like AP II manufactured by Computer A&T and the Micro II Computer are sold in the USA at half the price of the original Apple II. Such a low price is due to the importation of kits and sub-assemblies from Asian duty-free zones where products are manufactured for export with the benefit of tax levies and low labour costs.

In Brazil, the Apple II became very popular despite the legal ban on the imports of microcomputers. In 1983, according to different estimates, there were more than 10,000 imported units installed locally. Local manufacturing was introduced in 1982 by Spectrum, followed by Unitron and Polymax. By the end of 1984 there were about 15 local firms manufacturing Apple clones in

Brazil (See Table 1).

TABLE 1 - Apple II - Compatible manufacturers in Brazil

Manufacturer	Model	Memory Cap. (RAM-KBYTES)	Introduction
Apple-Tronic	U6502	48	1983
C.C.E.	Exato	48	
Dismac(**)	D8100	48	
D.M.Eletrônica	DMII	48	
Magnex	Manager II	64	1983
Microdigital	TK2000(Color)	64	
Micronix	Dactron	48	
Micronix(**)	Dactron E	64	
Milmar (**)	AP II-Plus	48	
Polymax	Maxxy	48	1982
Spectrum	Microengenho I	48	1982(1^{st} Apple in Brazil)
Spectrum(*)	Microengenho II	64	
Unitron	AP.II	48	1982
Victor do Br.(**)	Elpa II Plus	48	1983

Source: Revista INFO - Direct data Collection.

(*) Similar to AP.IIE
(**) Similar to AP.II Plus.

Tandy/Radio Shack, the manufacturer of TRS-80, is one of the oldest names in the world microcomputer market. Along with Apple and Commodore, it practically invented the micros and established a technical standard followed by many new firms. Among its best known American clones makers are Microcomputer Technologies, LNW Computers and American Computers. They usually sell TRS 80 look-alike

micros at lower prices than Tandy itself.

In Brazil many firms have reverse engineered the various models of the TRS-80, working from the Z-80A microprocessor supplied by Zilog. The best known manufacturer is Prologica which became Brazil's market leader with the CP 500 model introduced in March 1982. It was followed by Sysdata, Digitus, Milmar, Jamper and Kemitron. Table 2 shows the Brazilian TRS-80 compatible manufacturers.

TABLE 2 - TRS 80 - Compatible manufacturers in Brazil

Manufacturer	Equipment	Operational System	Processor	Memory	Introduction
Digitus	DGT-1000	DOS e CP/M	Z80A	64K	83
Jamper	JP-01	DOS	"	16K	
Jamper	JP-02	DOS	"	48K	
Kemitron	NAJA	DOS e CP/M	"	64K	
Milmar	TRS-80	DOS e CP/M	"	48K	
Prológica	CP-300	DOS	"	48K	ABR./83
Prológica	CP-500	DOS e CP/M	"	48K	MAR./82
Sysdata	JR.I	DOS	"	16K	ABR./83
Sysdata	JR.II	DOS	"	48K	84

Source: INFO, nº 18, Julho 1984.

Hewlett-Packard is the only foreign-owned firm authorized to manufacture microcomputers in Brazil. It was given permission to sell desk-top microcomputers for scientific and technical applications, since these involve sophisticated software technology not available locally. The HP 85 cannot be easily copied because it was designed around a chip which is exclusive to Hewlett-Packard itself. It also uses an operational system (HP Basic) developed

in-house and not compatible with other firms' hardware.

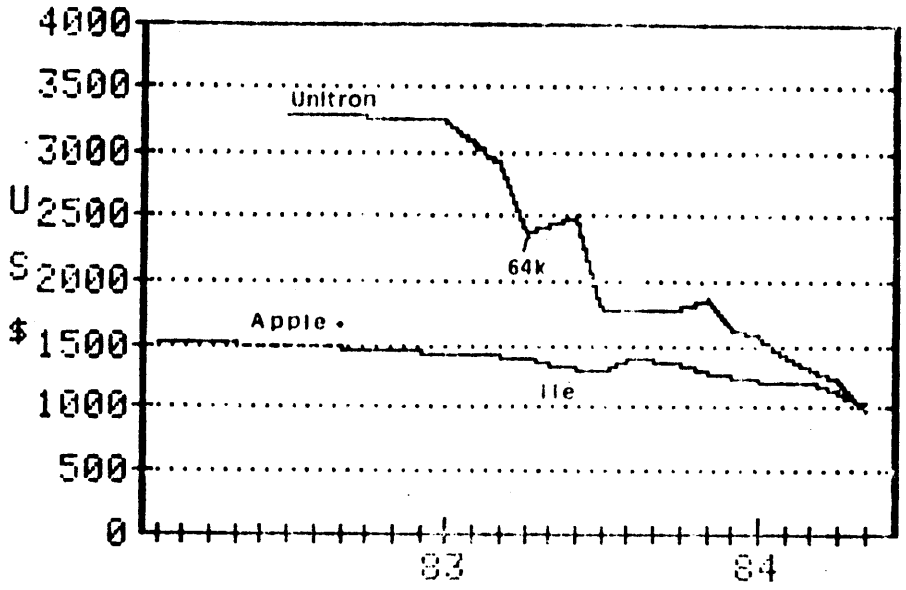
Measures of Competitiveness

There are two approaches to the question of competitiveness: the first is to compare the price difference between equipment manufactured locally and overseas. The second is to compare performance and technology up-dating.

As far as prices are concerned, I have found in recent research that there has been an impressive improvement in the price competitiveness of locally manufactured microcomputers. In 1982 when Unitron, the best seller Brazilian Apple clone, was launched, the relation between the CPU price in Brazil and in the USA was 2:1 ($3,295 against $1,530, see Figure 1). Since then the price in Brazil has been falling steadily and at a comparatively higher rate than in the USA. In May 1984 the CPU price became equal in both countries. During that period, the dealers' price in the USA fell 34.7% while in Brazil it corresponded to 70%. Another Apple-like microcomputer - Polymax - had the price difference reduced from 163% in November 1982 to less than 8% in May 1984.

In 1982, when the Brazilian Apple-like microcomputers were initially introduced, they were clearly not price-competitive with the original equipment bought in illegally. Dealers offered imported equipment at only 50% above the American price, converted into cruzeiros at the black market exchange rate (from 15% to 30% over the official rate). Most corporations, though, for legal and guarantee reasons, preferred to buy from local manufacturers.

FIGURE 1 - Evolution of the CPU price of Unitron in Brazil and Apple II / IIe in the US.



However, the market for personal use was mainly supplied by American equipment. One year later, the prices of imported and locally manufactured equipment were in level terms, due to the devaluation of the cruzeiro and cost reductions in local manufacturing. In May 1984 the illegal imports were restricted to floppy disk drives and printers.

Table 3 and Figure 2 provide further the relative prices of Apple-like microcomputers manufactured in Brazil as compared to the original equipment in the American market. Brazilian Apple-clones are, on average, 36.6% more expensive. Such difference is mainly due to the price of floppy disk drives (125% more) and video display units (283% more). In CPU terms the average price difference is only 8.2%.

TABLE 3 - Comparative prices of the Apple IIe in the USA and Brazilian-made Apple clones. May 1984. US dollars

EQUIPMENT	CPU (64K)	1 DISK DRIVE	MONITOR	INTERFACE DRIVE	COMPLETE SYSTEM[7]
Apple IIc (USA)[1]	999	299	99	102*	1,499
Milmar[2]	1,144.7	561.9	415.9	131.0	2,028
Dif. 2/1	1,145	1,879	4.20	1,284	1,353
Unitron APII[3]	990.9	684.4	325.9	130.4	1,918
Dif. 3/1	0,991	2,282	3,291	1,278	1,279
Maxxy[4]	925.7	684.4	324.9	130.4	1,860
Dif. 4/1	0,926	2,282	3,291	1,278	1,240
CCE Exato[5]	1,043.7	647.9	415.9	131	2,014
Dif. 5/1	1,044	2,166	4,201	1,284	1,343
Microengenho[6]	1,298.8	782.3	412	195.5	2,420
Dif. 6/1	1,300	2,616	4,161	1,917	1,614
Average[7]	1,080.7	672.2	379.1	143.7	2,048
Dif. 7/1	1,082	2,248	3,829	1,408	1,366

1) Source: Computer and Electronics, May 1984.

2) " Casa Garson - Rio

3) " Clappy - Rio

4) " " "

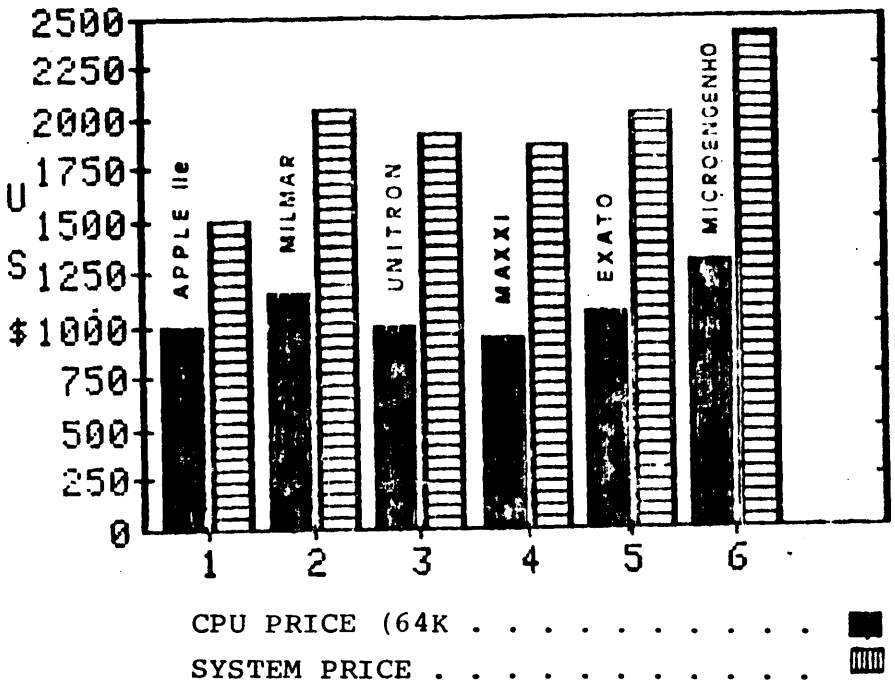
5) " Casa Garson - Rio

6) " Mesbla - Rio

7) Including 10% discount price.

8) Estimate.

FIGURE 2 - Apple IIe and its compatibles manufactured in Brazil



The analysis of the TRS-80 line has also revealed improvements in price-competitiveness of locally-manufactured clones. From January 1983 to May 1984 the CP 500 micro manufactured by Prologica had reduced the Brazil-USA relative price difference from 2.79 to 1.42. Other manufacturer (Sysdata) was selling a similar equipment cheaper than in the USA. In May 1984 the average overprice in Brazil was 18% (See Table 4 and Figures 3 and 4).

FIGURE 3 - Evolution of the TRS 80 model III price in the US and its clones in Brazil

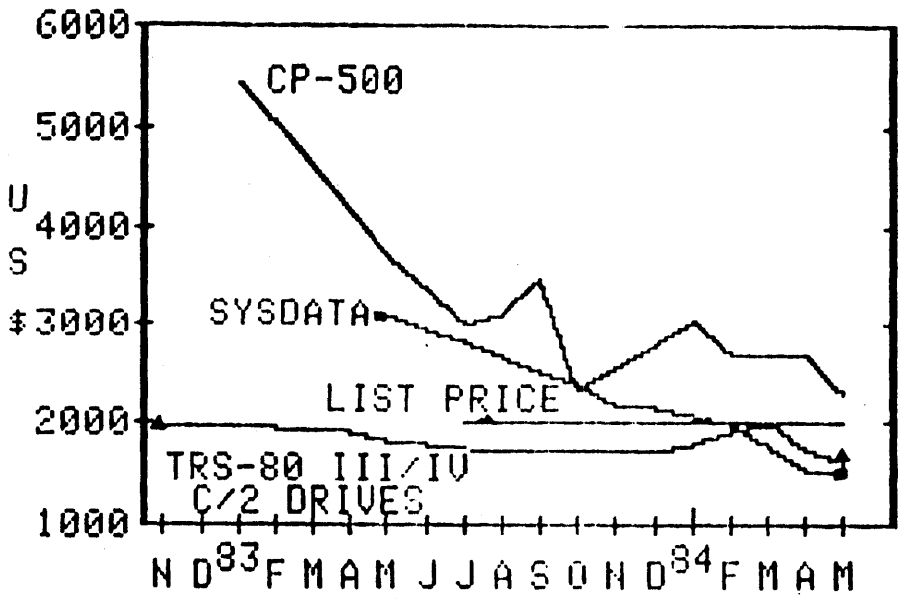


TABLE 4 - Market prices of the TRS 80 model III in USA and its clones in Brazil

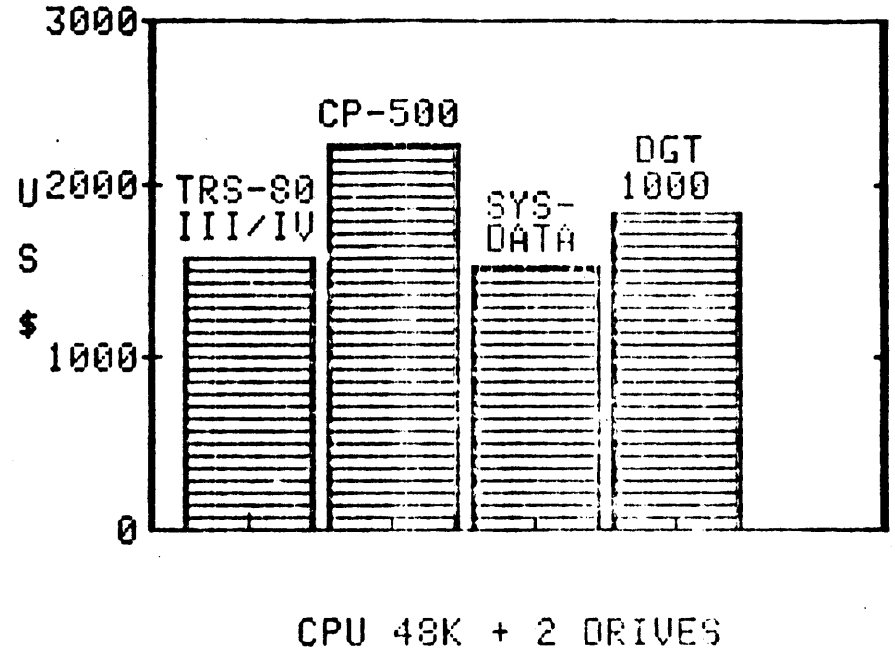
MODEL	CPU 16 k			CPU 48k/64 w/ 1 drive			CPU 48/64 w/ 2 drives		
	Cr$	US$	DIF. B/A	Cr$	US$	DIF.	Cr$	US$	DIF.
TRS-80 III/A IV	-	799	1,00	-	1385	1,00	-	1579	100
CP-500[1]	-	-	-	2800	1825	1,31	3450	2249	142
CP-300	-	-	-	-	-	-	-	-	-
SYSDATA JR.[1]	510	332	0,41	1463[2]	954	0,67	1728	1522	0,96
DGT 1000	890[1]	580	0,72	2157	1310	0,95	2818	1837	1,16
MÉDIA*		456	0,56	2140	1363	0,98	2665	1869	1,18

(1) May/84

(2) Sysdata Jr.II (48k + 1 Drive)

(*) Cr$/US$ 1.534,00.

FIGURE 4 - Market prices of the TRS 80 model III and its clones in Brazil



Hewlett Packard of Brazil also reduced the price of the locally manufactured microcomputer HP 85 significantly. From November 1982 to May 1984 the price difference went from 2.746 to 1.375 (See Figure 5).

FIGURE 5 - Evolution of the HP 85 price in Brazil and USA.

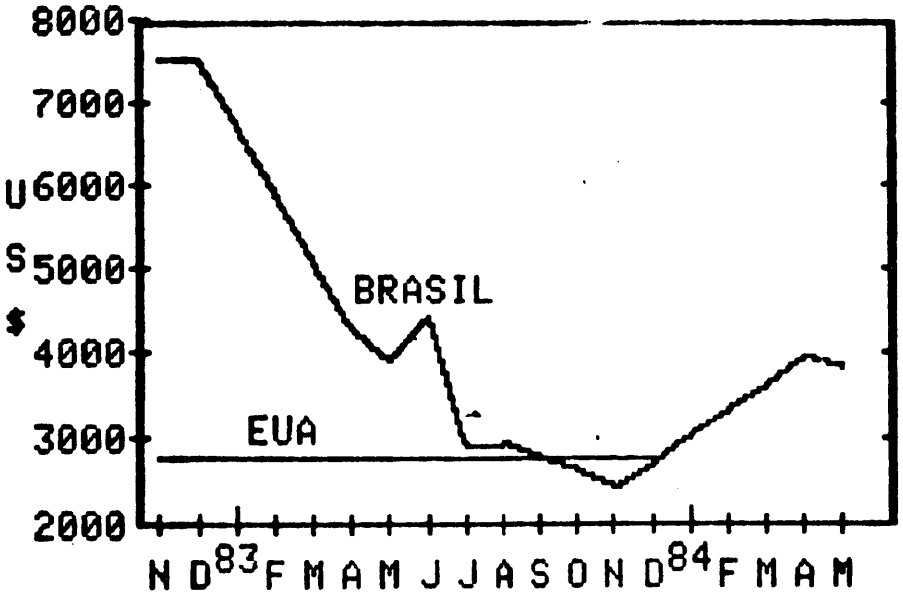


Table 6 shows the average price difference between the various microcomputers manufactured in Brazil and in the US. It can be noted that HP presents a slightly higher price difference than the average Brazilian manufacturers. This shows that local manufacturing by multinational corporations does not necessarily grant a better price to local users. This occurs because multinationals usually adopt a centralized, worldwide product strategy. Consequently their computers contain a lower proportion of local components than products designed locally. In some cases, simple components are imported because local subsidiaries are not flexible enough to make the product changes required to utilize locally manufactured components. Due to tariff barriers, there is a likely connection between the content of locally manufactured components and price competitiveness.

TABLE 6 - Average price differences between computers manufactured in Brazil and in the US.

Product Line	Average price Difference	
	CPU	System (Monitor, CPU + 2 Drives)
APPLE II	8,2%	36,6%
HP 85-A	-	37,5%
HP 85-B	-	48,8%
TRS 80	(2,0%)	18,0%

The research did not include detailed price comparison with countries other than the US. However, a study published by Creative Strategies International showed that in Mexico, in 1981, the price of the original Apple II Plus was twice as much as in the

US. The price difference was due to higher sale costs and profit rates obtained by local dealers, since the equipment was in great demand. In that year Apple Inc. sold 2,000 microcomputers locally, corresponding to a 40% market share.

The Mexican case shows that a liberal import policy does not necessarily benefit final users. By the end of 1981, the Mexican government introduced import restrictions for microcomputers as a part of a policy designed to develop a local industry.

Brazilian microcomputer manufacturers' executives interviewed distinguished two major reasons for price reductions: learning and economies of scale. The learning process enabled manufacturers to increase produtivity and improve the pace of stock rotation. Stock rotation is very important to save working capital at a time of high inflation (250% a year) and high interest rates.

The larger scale of operations enabled the dispersion of engineering and management costs over higher production levels. Some firms started manufacturing only 10 units a month and now produce over 400. Consequently they could introduce new equipment such as automatic insertion of components, thus obtaining important cost reductions. Intense competition in the Brazilian microcomputer market pushed firms to concentrate efforts in reducing costs and prices.

The observed improvements in the price competitiveness of Brazilian microcomputers has important policy implications. The decision whether or not to promote a new industry should not be based on initial costs considerations only. It must take into account the market growth perspectives and the learning capacity of local firms. Protection against foreign manufacturers may constitute a charge for end-users. However, if technical capabilities are

built and market potentials explored, local products might became competitive in a short enough period to make the present value of future benefits (discounted at an appropriate rate) larger than the costs of protection.

Technology Gap

The imitative strategy pursued by most microcomputer manufacturers implies the existence of a certain technology gap, since they tend to copy products which are already available in the international market. In Brazil, local manufacturers have succeeded in incorporating innovations introduced in the Apple II and TRS 80 with a gap of less than a year. In 1984 changes included keyboards and display expansions, higher electronic board density and memory expansions. The introduction of these minor changes in locally manufactured equipment is only a question of time, since they do not involve major technical difficulties for local manufacturers. It can be argued, therefore, that in those product lines there is a small gap in product specifications but not in technology. A technology gap occurs only when leader firms introduce completely new products or devices which technology are not acessible or fully understood by competitors. In that case, there is not only a gap in product design but also a technology barrier for other firms.

Identification of the technology gap between equipment manufactured in Brazil and abroad is important. Even more important, however, is to evaluate the importance of such a gap for local users. Sometimes, product changes introduced abroad are less important for local users than less sophisticated devices designed to match local

requirements -- as, for example, keyboards with Portuguese language characters. According to Prologica, 80% of its customers are small or medium-size firms using data processing for the first time. They use microcomputers to perform a limited range of operations such as payroll processing, stock control and accounting. So, most firms are not really interested in special features of the type required by the sophisticated American market.

The imitative strategy does not necessarily imply the notion of dependence. Firms which mastered reverse engineering techniques are independent in their technical choices. They usually reproduce solutions adopted by foreign manufacturers utilizing a more limited choice of components, since they have to comply with government requirements of high content of locally manufactured components.

Firms which adopt reverse-engineering as a product strategy are not necessarily interested in copying a good product design. Rather, the main advantage of such a strategy is to become compatible in software and to join a market which is already known by final users. Computer brands such as IBM and Apple are becoming a "de facto" standard in the world market. Only a small minority of firms in any country are willing to follow an independent standard for microcomputers. Even traditionally innovative firms such as Tandy/ Radio Shack are turning to the production of microcomputers compatible with the IBM PC. In Brazil, a technical director of an Apple-clone manufacturer mentioned that, during the reverse engineering process, they found a mistake in the circuitry design of the original equipment. After examining alternative solutions they decided not to change the original design, because this would imply a loss in compatibility. So, it is necessary to keep even

mistake compatibility in order to gain access to the "Apple market" which represents about 1/4 of the world microcomputer market.

However, keeping compatibility may become a difficult task in the near future. Although the new Macintosh microcomputer launched in February 1984 by Apple Inc. utilizes a standard microprocessor (the 32 bit MC 68000), it has some exclusively designed integrated circuits such as the DMA device for memory access and the parallel interface controler. Since compatible manufacturers cannot buy such components in the market, they may face problems in designing products fully compatible to the Macintosh. According to computer designers, some Brazilian firms already have technical capabilities to design and develop advanced 32 bit microcomputers. However, they could hardly produce twin copies of the Macintosh as they did with the Apple II.

It is difficult to predict whether the imitative strategy is limited in time. But if copying successful products at competitive costs became impossible, there are two alternatives to the local industry. One is to enter joint venture or licensing agreements with the world industry leaders. Such a strategy is already being pursued by Brazilian manufacturers of superminis and mainframe computers.

The other is to keep independence by boosting local research and development activities in a strategy designed to master the know-how required to develop original products or products compatible with the industry leaders but utilizing different technical solutions.

The first alternative has the advantage of being less risky for individual firms than the second one. However it has some important limitations such as:

- licensing strategy depends on the willingness of licensors

to release technology early in the product cycle. Although there is evidence that most multinationals are becoming more flexible in exploring their technology assets overseas (See Baranson, 1978) it is hardly likely that IBM sells technology without equity control.

- Products manufactured under licensing have typically poor export perspectives (See Tigre, 1982).

- Licensing presents fewer opportunities for learning by doing and technology advancement than local product development.

The second strategy is obviously more risky and requires a higher degree of state intervention. This includes protectionism and government investment for developing local technical and scientific infrastructure and financial support for firms' R&D activities. However it has the advantages of opening wider possibilities for local industry long-term survival, exports, appropriateness for local needs and technology autonomy in a field which constitutes cutting edge of modern industry.

The choice between these two strategies is mainly a matter of political will. However, some kind of combination of strategies in different market segments will probably be necessary in order to keep the national goals of technological development compatible with the individual interest of users and manufacturers.

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