WE MUST INVENT OR WE WILL BE LOST: THE POWER OF SCIENCE IN LATIN AMERICA

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INTRODUCTION

One of the key words in Latin America in the last 40 years has been “modernization”. Under its spell, the social and economic landscape of the region changed significantly. Is the 1950’s and 1960’s the was about the absence of scientific capabilities, a lack of students enrolled in higher education, the inexistence of postgraduate training, the need to establish a minimum base for research and development (R&D) activities, and the urgent need to create science and technology policy instruments to help set up a favourable environment for science and technology development.

Conditions today appear to be quite different. There is a relative abundance of qualified staff, the postgraduate level has been established and is growing, there is a wide range of R&D institutions, one can speak of scientific and technological communities in different fields, and some countries have begun to participate as exporters in the commerce of technology. However, parallel to these favourable changes, there is also a “brain drain”, unemployment of scientists and engineers, high rates of drop outs and repeaters among university students, premature obsolescence and vulnerability of research and teaching institutions, and R&D expenditures that grow more slowly than the growth of qualified human resources (with 2.5% of world scientists, the region was responsible for 1.8% of the world R&D expenditure in 1980). Arguments relative to the R&D capability of Latin America today not infrequently insist that much of what is done is unessential when not downright trivial (Goldstein, 1989). Keen observers of the region e conditions expect that in the coming years science and technology capability will undergo a process of accelerated obsolescence, and will therefore become increasingly out of step with the social and material needs of the population (Sagasti, 1989).

It may be said that, despite real advances, the Latin American R&D systems have not kept pace with international development, and continue to be deficient. There is already a research capability, but it excels only in a series of more or less isolated enclaves that do not manage to alter the general. Conditions are such that, in more than a few cases, the very weight of the often low quality, obsolete, and bureaucratized institutional research infrastructure acts as a powerful obstacle to change. Latin American universities are mostly too politicized and controlled by sef-serving interest groups and national systems are handicapped in their capability to create the scientific and technical profiles required by the production systems undergoing deep transformation under the current revolution in the industrialized countries. Probably no single country in the region is in condition of facing by itself the technological challenge of coming decades. The aims and direction of the regional scientific development must be rethought, taking into account the past 40 years of effort, new international challenges, old and new social and economic demands, persistent productive heterogeneity, and acute financial scarcity.

SETTING THE RESEARCH AGENDA FOR MODERNIZATION, 1940-1970

Theories of economic progress were common in the region before World War II[1]. During the 1930’s and 1940’s, a few scientific leaders were advocating government support of fundamental research, usually on a shared basis with international support, as a means of constructing scientific communities and economic development, assumed to be causally linked. The immediate pre-War

[1] For a recent exploration of the evolution of the notions of economic progress and development of colonized and developing countries in the first half of the twentieth century, see J.G. Alcalde 1987.

period witnessed, in a few countries, some attempts at increasing institutional activities and public policy mechanisms to establish a national research capability[2].

The Great Depression followed by World War II inaugurated a period of growth of industrial activity in Latin America. This period greatly influenced the future development of research activities in the region. The domestic manufacture of final products was given priority, substituting imports without worrying about ensuing technological dependence. Most technology transferred to Latin America was embodied in equipment and procedures. Selection, negotiation, acquisition and assimilation of disembodied technology were largely ignored; the same happened with national R&D. Tariff policies, capital mortgage practices, and lack of control in the payment of technical assistance and royalties rendered insignificant the cost of technology imports for the individual entrepreneur. On the contrary, the absence of protection for production of capital goods and the lack of stimuli to technology investments increased the risk and the time needed for technological investments to ripen. Objectively, this made the domestic technological development more expensive. This explains the late development of the capital goods sector (Chudnosky et al. 1983), the late start postgraduate education (Klubtschko, 1986), the marginal structure of experimental R&D (Antonorsi and Avalos, 1980), and the still very low entrepreneurial participation in the financial support of these activities (Katz, 1974). All these factors have shaped the region a current industrial situation (Fajnzylber, 1983).

Despite the fact that the general industrialization pattern adopted did not foster the growth of dynamic R&D systems, the strength of the modernization ideal helped both university and government research to acquire momentum in several areas, particularly since the 1950's (for a review, see Vessuri, 1987). Universities were the centerpiece of the charter for national science policy, indeed the only institutions to which it seemed to apply explicitly[3]. The aim was to form a "scientific-technical" infrastructure, assuming, often implicitly, that, on reaching a *critical mass*, there would be an automatic reinforcement of local technological, especially for explointing the opportunities of development of raw materials and other domestic resources. All of this would increase both production and productivity. The stage for a public policy for science and technology, which fructified in the 1960's, was set in the 1950's, and its most vocal spokemen were leading figures from the academic scientific community.

The national elites in academic science, generally with the technical-ideological help of international agencies, managed to convey to several Latin American governments and to influential circles of local societies the view that there was a one-way flow of ideas from fundamental research through development to commercial or operational application. This model was appealing because it was simple to interpret and transmit. For many years, nobody, contradicted this view of the genesis of technological innovation, a model that was also of political benefit to academic scientists in their claim for public support (see Bloch, 1987; Avalos and Viana, 1985). In the real world, however, things did not function according to such simple, elegant picture. In practice, this scheme helped increase the number of higher education and research institutions as well as of researchers, but was unable to reinforce local technology, which remained incipient and continued to complement technology, without much influence on the productive structure.

[2] Such was the case of México, with the creation in 1935 of the Consejo Nacional de la Educación Superior y de la Investigación Científica (CONESIC) (R. Casas, 1985); and Argentina's YPF specialized laboratory in Florencio Varela in 1935 and the Technological Institute in the Secretary of Industry and Commerce in 1945, which was INTI's direct ancestor. See oslak, O. 1976.

[3] It is hardly surprising that much of the debate about national science policy programs in Latin America revolved around the role of the university, particularly in its research role and as a provider of highly qualified personnel. After all, in most countries, universities accounted for a substantial proportion of existing research capability.

THE REGIONAL R&D ENVIRONMENT

The homogeneity derived from the common cultural base and single language spoken by 400 million people (with two mutually intelligible subdialectal variations, Spanish and Portuguese) and the heterogeneity resulting from very different demographic, economic, and political conditions between the countries is not an easy combination, leading to frequent questions about the existence of one or several Latin Americas. The uncomfortable combination of fundamental similarities and profound differences in the region is also reflected in the R&D schemes (Table 1). Only them countries, Argentina, Brazil, and Mexico, with between two-thirds and them quarters of the regional R&D expenditure (76%), researchers (66%), and university graduates (72%), have emerged as exporters of technology (Sagasti and Cook, 1985). Three national experiences linked to promoting local R&D illustrate some of the strengths and weaknesses in the region's research capabilities.

Argentina and atomic energy

Probably the earliest country to develop a scientific and technological base was Argentina. In 1950, the qualified human resources in the economically active population (EAP) was at 27.8%, the highest in the region. Likewise, employers, managers, and professional and technical staff accounted for 12.2% of the labour force, far ahead of other Latin American countries (Rama 1984, cited in Brunner, 1987). In fact, the availability of highly trained personnel has not been a problem in Argentine science and technology development, except for punctual specialties. More problematic has been the country's inability to retain its researchers. Low salaries, repeated political and economic instability, and persecution and regression have caused a good portion of the scientists and engineers to emigrate and discouraged the scientific vocation among the youth.

Argentina evolved from low-level production and automation skills in the last quarter of the 19th century to plant engineering in the first half of the 20th century. This was linked to agroindustrial food firms, textiles, building materials, and some final chemical and electrical products. Immediately after World War II, the country's condition was solid, appropriate for the creation of local industry, there was a good resource base a high level of income, and the state apparatus had some experience in economic management and the capability, in some sectors, to establish an adequate scientific and technological infrastructure.

By the end of the 1950's the industries producing intermediate goods of diffuse use – such as chemical and petrochemical – and those producing some durable consumer goods – such as the car industry – became central in the substitution model. Until the mid-1970's there was an uninterrupted growth of the industrial sector, which was accompanied by structural heterogeneities and diversity of performance. An interesting development from this period was that of atomic energy (see Westerkamp 1975; Mariscotti, 1985; Pyenson, 1985). The goal of the National Commission of Atomic Energy (CNEA), created in 1950, was to establish a national scientific-technological capability of autonomous decision-making in atomic energy and its application (Sábato, 1973). The education of highly trained personal received maximum attention; about 1000 scientists and technologists were sent abroad and some 350 foreign experts collaborated in the training of staff. The maturation of this experience was reflected in the construction of the Atucha Nuclear Power Station, which was the first case, in Argentina and Latin America, of a complex, "high" technology, involving local staff and industry. Contrary to usual practices at the time feasibility reports and preinvestment studies were done by CNEA itself and local industry contributed 40% of the inputs (Sábato et al 1978).

The atomic industry, however, remained one of a few relatively isolated enclaves. It was protected from the vagaries of local political crises, economic fluctuations, and distributive and clientelistic practices by the alliance of academic scientists and the military. This became particularly clear when, after a deep desacceleration of the industrial and economic growth by the early 1970's, the military government attempted a radical modification of the economic structure of the country, its social base of support, and its insertion in the international division of labour, through a return to a structure based on comprative advantages related to primary production and its early phases of elaboration[4].

The displacement of the industrial sector as the dynamic nucleous of the economy witnessed very different behaviours depending on the types of firm, sectors and marketability of the produced goods, defining a very complex and heterogeneous scenario (Azpiazu, 1989). As concerns the atomic national experience, however, the institutional stability and access to public funds insured by the military revealed themselves as necessary components for the start-up phase, absent in other unsuccessful attempts at modern technological development like the Argentine computer industry (Adler, 1987). The continuity of the goals of a national plan through time, allowed the generation and development of successful technology firms such as INVAP. However, without entering to argue the economic and social costs involved in such development, the very economic and political trends in the local society, and, ultimately, the new changes in the conditions of international competition put in evidence the limited strengh of the ideological commitment of the social actors involved in achieving a greater degree of autonomy in technological decision-making (what Adler calls the “intellectual guerrillas”).

The Brazilian Computer Case

In contrast with Argentina, in 1950, Brazil had a very small High stratum of employers, managers, and professional and technical staff (only 2.2% of the economically active population). In 1980 this had reached 10% (Rama, 1984, citated in Brunner, 1987)). If a country wishes to modernize, it must have an educated population. By the end of the 1970’s only 11% of Brazilian 20 – to 24 year – olds were enrolled in higher education; currently this value is even lower (10%) (Costa Ribeiro, 1989). In 1985, 22.3% of the population was illiterate. Despite this serious social and educational handicap, Brazil has experienced a dramatic expansion in R&D. Today, it has the region’s largest research community, with some 53,000 researchers (Martins and Queiroz, 1987). Although only 26% of researchers hold doctoral degrees, 56% of researchers have postgraduate training. Given the cointinuing government effort in training, the doctoral level will likely become predominant. The enormous regional differences are stricking. Southeast Brazil is home to 54.6% of the researchers, with São Paulo State having 26.9%.

Like Argentina, a well-organized group of Brazilian physicists committed to nationalist ideals, established a domestic microcomputer industry, another of the few Third World success stories in high-tech development. The experience started in the early 1970’s as an academic effort to create a critical mass of researchers in computer science, associated with the actions of a few government agencies such as the Navy and the National Bank of Economic and Social Development (BNDES). An industrial policy for this sector began to be defined. Its main feature was to exclude foreign firms from the cheaper and simpler segment of the computer market: mini – and micro-computers and their peripherals. Such exclusion, which caused a prolonged political dispute with the USA, was justified by the fact that the MNCs installed in Brazil were not interested in developing or absorbing the local technological efforts in view of the centralized nature of their R&D activities. Besides, the presence of MNCs in the market inhibited the emergence of local industries better integrated with national technology (Evans, 1986; Tigre, 1987).

In 1974, the public firm COBRA (Computadores e Sistemas Brasileiros) was created. COBRA develops and produces small data-processor systems. It absorbed many of the university groups involved in the initial project. Since the late 1970’s many national firms came into being, some of them founded by local computer researchers. The emergence of a genuinely national industry provoked an intense demand for qualified R&D personal. Given the incipient stage of informatics locally, the most common sources of R&D personal were the teachers and pupils of the local postgraduate programs. In 1984, the national firms were using 1750% more highly trained local professionals in developing new products than the MNCs installed in the country. This meant

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[4] However, those very activities suffered the accentuated deterioration of the exchange rate which made unviable any competitive possibility (not only in the world market but also in the domestic one) of local procution.

a basic difference relative to other sectors developed through the investment of foreign capital. As one anonymous commentator put it, “which were the automobile engineering courses stablished in Brazil as a subproduct of the industry implanted almost 30 years ago?” (Anonymous, 1984).

The sudden migration of university teachers and graduate students to the entrepreneurial sector contributed to the inadequate training of new teachers. In fact, the universities have been neglected in Brazilian informatics policy in the last few years (Schwartzman, 1987). Weakening high-level technical education endangers industrial development, not only in terms of human resources but also in terms of maintaining a certain measure of national technological autonomy, to the extent that research is not being carried out in advanced areas that are ultimately the ones that my lead to industrial development.

The importance of protectionism in cases such as this cannot be exaggerated. Market reserves like the one imposed by Brazil through the National Informatics Policy in 1976 have also been used by developed countries in phases in industrial implantation and consolidation and to protect industries at times of crisis. Nevertheless, pressures to open up the Brazilian microcomputer market to foreign industries have been strong both outside and within the country, and political and economic crises have certainly cooled the enthusiasm with which scientific and technological development projects are discussed. Mechanisms such as these which currently protect national industries will not be able to resist the “siege” of new technological for long. It has been argued that only technological maturity can act as a permanent guarantee for economic competitiveness in political and economic terms, and therefore guarantee survival and autonomy for the national productive system (Zagottis, 1989).

However, the success in informatics has led to strong demands to apply similar principles and objectives to other strategic areas in Brazil such as pharmaceutics, where 85% of the domestic market is controlled by MNCs. The idea is to make a better use of national research capability, to orient production in the service of societal interests, and to guarantee nonextortive conditions in buying products and inputs in the world market (Anonymous, 1987).

The Mexican National System of Researchers

To diminish the negative effects of the economic crisis of the 1980’s, Mexico created in 1984 a new program to reduce the brain drain at the level of elite cadres of its science and technology system, the National System of Researchers (SNI). Its three central objectives were to preserve the core of its national stock of researchers, to promote their improvement and productivity, and to foster the participation and self-evaluation of the research community (Malo and Garza, 1987; Malo, 1988). The key decision that defined SNI’s philosophy was that only those “researchers” with high levels of productivity and quality, as judged by their peers, and actively engaged in research could be part of the program. The program involves paying of a salary supplement proportional to the category in which a researcher is placed in the System. It has grown from 1,395 researchers in 1984 to 3,495 in 1987; the numbers seemed to stabilized in 1988, suggesting a saturation point[5]. The interest of young researchers is evident in the sevenfold increase in enrollment in the *Candidatos a Investigador Nacional* initial category in the first 3 years; the other two levels have increased less then twofold.

The main difference between SNI and Argentina’s *Carrera del Investigador* administered by the National Council of Scientific and Technological Research (CONICET) since 1961, is that, in the Mexican case, the linkage between the researcher and the System is only temporary (3 years). The researcher is evaluated annually and may reapply at the end of the 3-year period. In this way the Mexicans are trying to avoid the Argentine problem of paying people who have stopped being

[5] According to a recent estimate the number of Mexican researchers is around 7,000, although the total number of R&D personnel is surely substantially larger; postgraduate students in local programs number some 40,000 (Reséndiz Nuñez, D., 1987).

productive[6]. In both cases, through, the main objective was to avoid brain drain and insure the full-time commitment of the researchers to research activities[7]. On the other hand, the Venezuelan government partly under the inspiration of the Mexican experience, is inclined to respond to a growing demand of the scientific community, developing a Program of Promotion of the national Researchers. Such program, still in existence only on paper, has been granted an initial budget in 1990.

From the examples above, then, it may be elicited that however interesting the attempts at developing viable industries with considerable levels of national autonomy, and however valuable the scientific and technical specialist communities that were built in very specific fields, they remained in most cases as more or less isolated phenomena. Among present challenges there is the need to root R&D more deeply in society in society, and make it economically, socially, and culturally meaningful. The current Mexican experience of the SNI aims at making of academically based research a main source of competence to support long-term national development policies. Argentina's 20,000 researchers are given support by an State system which has its heart in the Science and Technology Council (CONICET) (SECYT, 1989). Brazil's researchers are also supported by a system in which CNPq, FINEP, FAPESP, and other agencies have outstanding roles (for a recent review see Jaguaribe, 1987). The smaller countries also have a range of institutions involved in some sort of activity supportive of the research community. Wether the scientific and technological capability which is being supported and developed succeeds or not will depend on many other complex factors besides the availability of a skilled population ready to get involved in economic development and technological modernization.

Some of the difficulties in understanding the political and institutional realities that condition economic transformation can be grasped when considering the problems posed by the areas of application. To illustrate the problems faced by the region's R&D systems in contributing to the resolution of issues of national relevance, usually linked to basic needs or natural comparative advantages, we may examine two functional categories: agriculture and mineral resources. Implanted institutional models of research, the subjects catalogue of international cooperation programs, and the way foreign firms have acted in the region with regard to R&D activities have often hindered, delayed, or distorted the full development of needed capabilities in the local context.

AGRICLTURE Despite different national socioeconomic and political characteristics, a peculiar organizational R&D pattern, based on the Land Grant Colleges and Experimental Station System of the United States, was implanted throughout Latin America in the mid-1950's and early 1960's. Examples of this were the National Institutes such as the National Institute of Farming Technology (INTA) in Argentina (1957), the National Institute of Agricultural Research (INIAP) Ecuador (1959), the National Agricultural and Livestock Research Fund (FONAIAP) Venezuela (1959), the National Institute of Agricultural Research (INIA) Mexico (1960), the Agricultural Research and Promotion Service (SIPA) Peru (1960), the Colombian Agricultural and Livestock Institute (ICA) Colombia (1963), the National Institute Agricultural Research (INIA) Chile (1964). Their mission involved improving diffusion of technology already available in the industrialized countries. Consequently, the industrialized countries priorities for technological development were also adopted, within limits imposed by resource availability. In general, the resulting technology has been capital intensive and has centered on products of temperate climates and forms of production appropriate to the natural resources of the developed countries or with good prospects in the export markets, such as corn (Sábato, 1981), sugar (Piñeiro et al. 1982), milk, beef (Astori et al. 1979), and rice (Balcázar et al. 1980), disregarding the growth of capabilities to make fuller use of native productive potential (Texera 1982). Nonetheless, these institutions had considerable impact on the levels of production and yields of a range of products in which the economic conditions needed to adopt technology (Chapman et al 1983). In view of the particular socioeconomic aims of the agricultural

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[6] Currently, the *Carrera del Investigador Científico y Tecnológico* has 2,212 members; the *Carrera del Técnico y Personal de Apoyo a la Investigación Científica y Tecnológica* has 2,667 members (CONICET, 1988)

[7] Having two, three, or more jobs continuers to be a common feature of researchers in R&D systems of the region (Argenti, et al. 1988; Sagasti, 1988).

modernization process, the experience of the network of national research institutes might be judged a sucess[8].

In the recent years, however, international and national conditions have changed. The three most significant problems are:

- ✓ The qualitative nature of the prevailing agrarian modernization processes;
- ✓ The emergence of a more institutional model for technology generation, made up of different kinds of organizations, and within which the private sector becomes increasingly important, and;
- ✓ The growing internationalization of technology supply.

The new, private organizations focus their attention on technologies that, by their very nature, allow for the private appropriation of profits. Their activities cannot thus be expected to cover the development of functions for generating a “technological potential” in the broadest sense, that is, including education, training, etc.; without these functions, however, the ability of the rest of the system for developing new technologies would quickly be exhausted. Likewise, private organization will not assume specific activities of a generic nature (painstaking research, etc.) or with a low probability of bringing about immediate results. Finally, the new private organizations are not interested in developing certain agronomical techniques (cropping practices, pasture management, etc.) because of the difficulty of privately appropriating their benefits. This means that a broad range of users neglected by the new institutional formats can be served only by public organization; once more, the public sector must rethink its technological policy (Piñeiro and Trigo 1981). This would involve redefining the institutional formats of the National Research Institutes, which have reduced their efficiency in the last decades.

MINERAL RESOURCES Common trends in mineral resources are visible in most Latin American countries: export-led growth and infrastructural development of private (often foreign) firms in the mineral industry created a demand for engineering services. This demand was satisfied by foreign and, to a lesser degree, national engineers trained abroad and locally. However, there was a long delay in developing those areas of geology more linked to prospecting, inventory and assessment of mineral resources, economics, and applied geology. These areas are fundamental to provide a capacity of decision-making and autonomous choice (Carman, 1979). Despite an immense mineral wealth exploited since the early colonial period, the first four geology schools in Brazil were founded as late as 1957. Their general orientation was more “academic” than economic, except for the one located in Ouro Preto, where, since 1875, the School of Mines has trained exclusively mining, civil, and metallurgy engineers (Machado, 1988).

In Chile, the State created in 1957 the Instituto de Investigaciones Geológicas to develop the earth sciences both in their basic and applied aspects. In a country where the mineral wealth has always been an important component of the national economy, in several of the critical areas such as applied geology, economic geology, and marine geology and geophysics, the number of researchers remains very low (Corvalán, 1982).

In Bolivia, mining in the 20th century has been dominated by national capitalists and, yet, the great majority of engineers employed were foreign. Being Bolivia’s most important industry, mining is probably the most important employer of engineers. Most of these, however, up until the nationalization of the principal mines in 1952, were foreign. When the mines were nationalized, over 200 foreign engineers left the country. The newly created State mining company had great difficulty in replacing them: less than 100 Bolivian engineers had been trained in the previous 50 years. Apparently, the national engineers had better career prospects in civil than in mining

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8 However, the Institutes lost efficiency, among other things, because of their broad range of action resulting from the tremendous heterogeneity of agricultural production in Latin America. The North American “federal” scheme they copied was a response to high *regional* heterogeneity of the US agricultural sector, in the context of a relatively homogeneous production structure that facilitated the linkage to the different farming interest groups. On the contrary, the single-agency model adopted in Latin America tended to hinder such a relationship and to respond to the needs of many different groups, frequently with conflicting interest.

engineering; the latter was dominated by a large quantity of foreigners at a time of great international labour mobility. Therefore, there was more competition and even a certain discrimination against Bolivian engineers (Contreras, 1988).

THE POTENTIAL OF THE LATIN AMERICAN UNIVERSITY

Higher education experienced an unprecedented expansion from 1950 to 1980, increasing 20-fold from about 250,000 students in 1950 to 5,380,000 in 1980 (Tedesco, 1985). This growth took place in very heterogeneous array to learning institutions of unequal quality. The rapid industrialization of the largest countries produced a strong demand for science and engineering graduates able to handle operational and service problems of the new assembly industries. In a very politicized social context, full of secular unresolved problems, the universities began to turn out groups of frustrated nationalist technicians. There graduates had strong personal ideological interests in greater industrial autonomy that would allow them to deploy their acquired talents on behalf of their nation. For people who saw themselves as potential creators of technology in their own countries, the future they envisaged was hardly the kind of self-realization for which they had hoped (Evans, 1986). Witnessing this were the *Resovación* academic movements in most Latin American countries at the end of the 1960's (see Vessuri, 1984). The examples of developing atomic energy and computer industries in Argentina and Brazil, respectively, are but two samples of a common ideological commitment. Several others could be cited, such as the petrochemists of IVIC (*Instituto Venezoelano de Investigación Científica*) and the Central University of Venezuela, who were decisive in the creation of the Venezuelan Institute of Oil Technology (INTEVEP) (Vessuri and Diaz 1984) or the engineers of ITA (*Instituto de Tecnologia Aeronáutica*) who commited themselves to the creation of a Brazilian aircraft industry (Dagnino and Proença, 1987).

But industry has considerably underused locally produced skilled labour. Given the lack of a significant industrial demand in most countries from the 1950's to the 1970's, the professionals who remained in the universities were often frustrated because when they produced potentially interesting results, there was no way of transforming their creations into products. Besides, in an often too politicized academic environment. With permanent feuds between self-serving interest groups, and with increasing teaching loads, as the expansion of student enrollment became more pressing, the universities lost their attractiveness as a *locus* for research. Scientists and engineers tried, whenever they could, to organize their work away from universities (see Vessuri, 1984) or around well-insulated countries. The State must assume an active role in assessing and raising the quality of teaching programmes, controlling the proliferation of postgraduate courses and guiding research policies, both within the public sector and the new rapidly growing private sector (Levy, 1986). The multiplicity of institutions of higher education in the region need to be improved, strengthened and led strategically to serve effectively their host societies in the 1990's.

IN SEARCH OF WILL AND IDEAS

To the same extent that "*modernization*" was a key word during the first three decades following World War II, "*frustration*" is the term which best expresses the present mood in Latin America. Ideas of autonomy, self-reliance, alternative development, and social equity went out of fashion as the crisis of the 1980's became deeper. The region is exhausted, materially and morally. It is not only a question of the heavy burden of foreign debt, but also a deeper feeling of the society a failure to find an alternative road to development and the acceptance of a totally subordinate role in the world division of labour. The prevailing neoliberal ideology, enthusiastically embraced by segments of the political and economic lieadership throughout Latin Americam supposes joining the new international setting without retaining any measure of self-determination and without proving a solution for the unsolved and growing basic needs of the population.

The challenge facing the region is deeper than simply resuming the process of modernization after the "lost decade" of the 1980's. It is by now crystal clear that the classic distinction between "traditional" and "modernizing" societies has lost any substance. The oceans of misery found is Northeastern Brazil, in the Caracas "*barrios*", or Buenos Aires *"villas miserias*", are no less "*modern*" than the areas where prosperity and achievement prevail. As comparisons with other regions and socioeconomic patterns reveal, It is ultimately only an internally articulated and equitable society the one that generates conditions favourable to a sustained effort of incorporation of technical progress, increase of productivity, and, therefore, growth.

The ideology of modernization crystallized in the 1960's and 1970's, was purported to lead to increasing levels of autonomy, self-reliance, and social justice. The social dynamism it unleashed had manifestations in broad fields of activity, not only in one or another scientific discipline. To develop industries of the level of sophistication as the ones mentioned (in the Latin American countries capable of establishing them), there was something more than a small group of scientific and engineering specialists and their tactical allies. They more not drops in an ocean of indifference and ignorance. They were part of a social effervescence that, even through is did not coalesce in a social project, tried to enlarge the grounds for building better and more equitable societies. The hopes raised by the Cuban Revolution in the early 1960's contributed to bolster the self-esteem of the region's societies. Those were years of ascent of self-reliant movements, optimism, and hope, in sharp contrast with present feelings of gloom and disillusion.

The groups of scientists, engineers and government officials who at one time or other managed to put their projects in practice also got something else in the process. For a while, they managed to change the conditions of the competitive game by their unexpected achievements. The development of local capabilities in science, technology, industry, management, and labour skills introduced significant changes in the local social structures, created new sets of actors with technical and managerial skills, and gave them a better understanding of the art of negotiation.

But the changes they produced were insufficient to alter the background of social and economic conditions that ultimately led to the defeat of their attempt: a pattern of economic development based on growth without social equity (Fajnzylber, 1987); an industrialization oriented to the internal market and blased to a pattern of conspicuous consumption of luxury goods significantly higher than other late industrializing countries with comparable levels of income (Esser, 1987); lack of leadership of the national private firms (automobile, chemicals, capital goods) in the most dynamic industrial sectors, which are the carriers of technological progress and define the national productive profile (Anonymous, 1985 cited by Fajnzylber, 1987); little weight of the small and medium enterprises (anonymous, 1986); scarce participation of the national private sector in R&D activities even in the most advanced countries of the region (Katz, 1986); distortions and underdevelopment of entrepreneurial capabilities (Pirela et al., 1989).

The industrial sector in Latin America in the 1980's has been described in the following terms: relatively high margins of idle capacity in several countries and sectors and precarious financial situation of the associated firms, linked to the fall of the internal market; over-indebtedness and high interest rates; drastic fall of investment rates in several countries, increasing the age of the industrial park precisely at a time in which at the international level technological change accelerated in the sector of capital goods, leading in turn to an increase in the degree of technical obsolescence; weakening and in some cases dismantling of design groups in factory and engineering firms, and degradation in the qualifications of that part of the industrial labour force which, upon dismissal, moved to other activities (Fajnzylber, 1987).

In the public sector, the compounded effects of restriction of resources for investment, concentration of attention in the management of short-term problems with the consequent disregard of strategic thinking, and drastic fall of salaries in the public sector, has weakened public support in certain critical areas, such as the R&D activities. Thus, what is at state today is not a punctual difficulty but the whole social and productive system.

The construction of a desirable future will require an escape from present constraints. A good deal of decision-making freedom and autonomy are supplied by scientific and technological capabilities a nation has. Knowledge is, more than ever before, power and opportunity. Latin America, however, has not yet developed an enduring consensus on this. Policies for the science and technology sector have been of the *coups d'accordeon* type: at one time, there are not enough well-trained researchers to respond to the ambition of the programs defined by government; at another, finances cannot support the research capability developed. The most recent studies point to a serious deterioration of working conditions in the research field and a growing alienation of researchers, who lack stimuli and often the minimal conditions to pursue their work. In addition to this, a number of criticisms have been raised pointing out that much of what is done is inessential, through the ideology of "applied research", which may have contributed to consolidate the inadequacy of existing research capabilities (Goldstein, 1989).

At the same from time, the overall international situation continued to move in a dynamic process that has reduced the space available to Third World countries. The current process of internationalization of the economic systems is openly favourable to most industrialized countries and MNCs.

The individuals and groups who defended the development of local productive forces in Latin America from a position of self-determination have been defeated with the help of authoritarian regimes and local representatives of external interests. Today, the development of local scientific capabilities in the region is discouraged. The argument given is the abysmal differences in resources and the more practical, pragmatic, and efficient (oversimplified) example of the Japanese success in technological replication in place of scientific creativity. But the answer, stubborn as it may seem, appears as valid now as in the 1960's: to insure the existence and expansion of local research capabilities as a necessary although admittedly insufficient condition for success, which will ultimately depend on radical internal social transformation and careful international negotiations.

Strategies of technological autonomy are long term; therefore, they must be selective and flexible. It is crucial to have autonomy in the very basic decisions as to which technologies are to be included in the development plan. Therefore, the ability to devise imaginative solutions to what appear as insoluble problems, to create, adapt, and use significant technological systems and the ability to choose and control the areas of technological dependence must be insured. The option for Latin America continues to be the one put forward by Simon Rodrigues, Simon Bolivar's teacher, over 150 years ago: "We must invent or we will be lost" ("*O inventamos o erramos*").

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