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J. D. Bernal in a Latin American perspective: science for development?

Paradoxically, J. D. Bernal's preoccupation concerning the role of science with respect to society and mankind has been at the center of discussion in Latin America since the mid-nineteenth century (in Mexico since 1867, according to Casas, 1985), and it is still at the center of discussion today[1], 50 years after the publication of Bernal's book. In the more advanced nations, much of the scientific and technological development has been largely a natural by-product of the need to improve productive forces. In our societies, however, S & T development has been supported by official spheres as an intrinsic good that would naturally lead to social and economic development (Casas, 1985). One of Bernal's main preoccupations with the role of science was that it was subdued to a profit-motivated, capitalist economic and social organization versus a more desired "in the service of man" role (Bernal, 1939: 126—164, 345—384). In developing nations, science is subdued to a profit motivated *late-dependent*[2] capitalist organization, and its role tends to be that of being "in the service of *other* men"[3], because of the asynchronization between advanced scientific research and societal requirements.

This paper intends to provide a general background concerning the development of science and technology in Mexico, explore the system's nature and problematic, and expose some of the problems facing Mexican scientists today.

Science and the state: An Historical perspective

The most singular characteristic concerning the development of science and technology in Mexico is perhaps its historical dependence on central state support (Velasco, 1981). Private interests linked with the productive activity have not, as perhaps they have in more advanced countries, exhibited sufficient interest in improving uncomplicated, intensely labor based production processes. This element cannot be underestimated, for it is

perhaps fundamental in having rendered Mexican private industry virtually incapable of any technical exploitation of resources (Mayer, 1988).

Among many and complex reasons, the permanent overabundance of exploitable Indian and "Mestizo"[4] hand labor dating back to the colonial 16th century practically obliterated any need for innovation in work processes or productive activities in general. The Spanish and Spanish descendant ruling class were not of an entrepreneurial or innovative type, in part because they were occupied with administering the immense riches discovered in the New World. In addition, the economic and political structure was devised in accordance with the colonial condition of the region, which means that our forefathers had from the origins inserted their economies into a world context.

With the advent of the industrial revolution in Europe and the United States and the international division of labor, even before Latin American countries had firmly established themselves as nations[5], our dominant groups promptly directed efforts to satisfying increasing demands for agricultural and mineral raw materials, given their abundance and the hand labor to exploit them. This marked the beginning of a permanent subordinate relationship with respect to central economies. The new nation-states were thus forced to solely assume many of the tasks that were unfulfilled by a rather inactive economically dominant group, naturally devoid of national development projects. Among these tasks is S & T development.

The relationship between the state and S & T development in Mexico began in the middle of the 19th century, in the midst of a fervent liberal reform atmosphere. The Organic Law of Public Instruction established the need to spread the natural sciences throughout the nation in 1867 (Casas, 1985: 23). Although this legislation was soon reversed, this first precedent is indicative of an incipient governmental preoccupation with the lack of a scientific culture in the country.

It was however in the period 1920—1940, along with the dramatic social reorganization brought about by the successful culmination of the 1910 revolution[6], that S & T took on new meaning in terms of national development. This was initiated, however, not by the government, but by the Antonio Alzate Scientific Society, a prestigious organization of influential scientists. The society proposed the creation of the "Permanent Committee for the Promotion of Scientific Research" in 1927. This proposal emphasized the need to formally promote scientific research in order to achieve, they thought, economic and social well-being. Among their most important tasks were (Velasco, 1981: 404):

1. To train specialists in the different areas of human knowledge.
2. Political insulation for scientific activity.
3. Organization of a fund-raising campaign for research centers, fellowships and grants, and awards for outstanding Mexican scientists.
4. The promotion of a publishing infrastructure for scientific work.

Although these proposals never reached implementation, they nevertheless marked the first concrete attempt at "mending" a scientific system that had fallen behind in comparison to advanced nations.

President Cardenas' administration (1934—1940), obviously influenced by the Society's proposals, saw S & T development as the condition "sine qua non" for its ambitious industrialization program. This was a nationalistic plan oriented toward the development of a strong internal market, which included attractive incentives for investment to private local capital by way of tax relief, and subsidized energy consumption for industry. In order to support this plan by skilled professional and technical human resources (considerably more than half of the population in the country was engaged in agriculture), Cardenas founded the National Council for Higher Education and Scientific Research (CONESIC) in 1935. Its fundamental tasks were to oversee the creation and maintenance of research centers and institutions that depended on the government, and to aid in their program and budget elaboration (Casas,

1985: 26). However, the Council soon confronted stout conservative reticence, especially from the National University who saw its lecture and research liberties unjustifiably endangered. Cardenas was forced to abandon the project two years after its inception and the Council was dismantled having had practically no effect on S & T development.

What was left of the CONESIC was subsequently rearranged into the Steering and Coordinating Commission of Scientific Research (CICIC) in 1942. An important task of this Commission was to assist industry in the next administration's efforts to overcome a dangerous consumer goods shortage caused by World War II (Casas, 1985: 36). The war inflicted low production output of the advanced nations was forcing previously importing countries, like Mexico, to accelerate the creation of new industry to respond to the shortage crisis. Given the lack of expertise among Mexican private initiative, experienced mainly in producing primary agricultural and mineral goods for export, the government's urgent need to substitute imports was satisfied mostly by foreign direct investment, mainly from the United States (Mayer, 1988; Casas, 1985).

While the S & T system continued to develop, it was nevertheless confined essentially to the institutions of higher education, which were by then utterly divorced from the economic system (Casas, 1985: 43). Foreign multinationals, with their own R & D infrastructure in their home countries, had little if any motivation to participate in any national S & T development program.

The CICIC was subsequently replaced by an entity of higher hierarchy, The National Institute of Scientific Research (INIC) in 1950. Despite the existing coordination and mutual support among different instances related to the process of scientific research, the Institute became an obstacle for the development of science, and a period of stagnation settled in, which dragged on until the 1960's. A new private society of prestigious and influential scientists, The Academy of Scientific Research, attempted to revitalize the initial impulse of the previous two decades, and formulated a reorganizing project for the INIC, in 1960. The outcome of these efforts was not very encouraging. The most they were able to obtain was a limited number of research fellowships both in the country and abroad, and their distribution eventually did not correspond to a comprehensive analysis of the nation's needs in terms of the formation of human resources (Velasco, 1981: 404).

Despite the continued official pronouncements since the 1920's on the importance of a solid scientific infrastructure to support national socioeconomic development, and the incipient exhortations in a similar direction that international organizations such as UNESCO and OAS were making to Latin American nations in the 1960's, these lacked in ability to pass from theory to practice. To remedy this, the INIC formulated the first modern, coherent document concerning national science and technology policy in 1970. In order to implement it, the National Council of Science and Technology (CONACYT) was created at the end of that year (Velasco, 1981: 404).

Upon the foundation of CONACYT, science in Mexico experienced a quantum leap. It may be rightly said that we entered a new epoch and that the history of science should be separated into "before" and "after" the inception of CONACYT. Since relevant political decisions in Mexico are highly centralized in the presidency, changes in the official vision of science and technology were due primarily to the political will of support expressed by President Echeverría, during his term (1970—1976). It was precisely such will that led to the creation of CONACYT, and gave the important impulse to the establishment of new scientific institutions. Actually, CONACYT was the instrument devised by the government to channel two felt needs. One was the realization by the government itself of the importance of scientific research for economic development. The other was the need expressed by the scientific community for the formulation of a coherent scientific policy. CONACYT was given responsibility of the planning, programming, promotion, and coordination of

scientific and technological activities, as well as of the evaluation of results.

During President Echeverria's administration, the S & T federal budget grew continuously, having a net growth of 2.4 times between 1970 and 1976 (Saldaña & Medina Peña, 1988: 1114). In this period, 15 research centers were founded in the interior of the country, most of them dedicated to R & D related to regional needs or to mission-oriented technological research (Secretaría de Programación y Presupuesto, 1988: 14). The same impulse continued during the next administration, that of President Lopez Portillo (1976—1982). The S & T federal budget had a net growth of 2.1 times between 1977 and 1982 (Saldaña & Medina Peña, 1988: 1114). Since 1983, due to the economic crisis, whose first signs became manifest in 1981, federal expenses have been steadily reduced, affecting the S & T budget also. Between 1981 and 1987 the public S & T expenditure had fallen 26 % in real terms. Concomitantly, salaries for scientific researchers have steadily diminished. Between 1982 and 1987, the salaries of researchers at the National University fell 38.7 % (Saldaña & Medina Peña, 1988: 1114).

The reduction of support for scientific activities brought about some migration of the best qualified scientists, both in and out of the country. Those who decided to stay in the country left for high positions in either the public or the private sector. Those who went abroad accepted positions in research institutions mostly in the United States. In order to contain the stampede, and preserve the scientific community as much as possible, the federal government devised a mechanism of salary compensation called the National System of Researchers (SNI) in 1984 (Malo, 1986). It consists of a fellowship granted to the individual scientist according to his/her scientific merits. This system, thought to be an incentive for good performance, soon became an important part of the scientists' scarce income. Although the SNI has helped to reduce the migration of qualified scientists, it is not seen as motivating enough for young generations to dedicate themselves to science. The SNI is currently benefiting approximately 4000 scientists out of an estimated scientific community of 16000 individuals.

Science and modernization

An issue that has recently drawn national attention, one in which the S & T system would seem to play a fundamental role and thus lead to its potential revitalization, is the issue of modernization. According to the government, its leading advocate, modernization is a necessary condition for the eradication of traditional, inefficient edifices that hinder progress. This is an enterprise that intends to bring about profound social and economic change in the form of a more liberalized economy, industrial reconversion, and political reform, along with substantial reforms in education and S & T development (Mejía Núñez, 1988), all these directed toward the improvement of the quality of life of the population.

In a global perspective, modernization of industry is essential in order to keep pace with the profound transformations that are taking place on a world-wide scale and to maintain the country's current international competitiveness. Among the changes that these transformations bring is the dispersion of productive forces, whereby multinationals locate manufacturing facilities in different countries that correspond to different phases of the production process. The government also recognizes that the world is experiencing a new technological revolution, and that it is marked by an unprecedented rythm of technological innovation and dissemination, that modifies substantially productive and market structures, whereas competition is now taking place in terms of quality and innovation as opposed to a traditional price-based competition. At the same time, new technologies have brought about a reduced consumption of primary products, on whose exports many developing countries, including Mexico, still depend on for hard currency generation (Secretaría de Programación y Presupuesto, 1990).

For these reasons, the government is placing special emphasis on S & T modernization, specifically research that is directly linked to productive activities, in order to adapt in an agile manner existing industry to new technology and to develop a capacity to innovate and develop products and processes that will permit the country to compete effectively in the dynamic world markets (SPP, 1990).

The direction the government is attempting to take in S & T development seems to be quite clear. What is not so clear, however, is *how*, given the historical and structural shortcomings of the system, the link between S & T and economic structure is to occur, and in what areas the country intends to compete. Until now, modernization has meant mainly economic reorganization in favor of more efficient private capital accumulation. This has been accomplished by way of transfering previously state-controlled enterprise to private interests, aggresive initiatives to provide for a more flexible and efficient workforce, and modernization of the industry with new, imported, manpower-saving equipment and machinery.

For science, however, there is not much of a role to play in this context. History appears to repeat itself as the government is again forced to allow multinational enterprise to satisfy modernization demands that local private interests are not able to fulfill. We once again run up against a problem of insufficient scientific infrastructure to support serious programs like these. Evidently, modernization means more than allowing companies with state-of-the-art technology to operate inside national territory, or to import that technology, for that matter, as it affects many other aspects of society. However, inasmuch as a national S & T context is concerned, it means very little, other than a deeper dependence. But in this, the scientific system itself is not completely without fault.

In Mexico, as perhaps in many other countries, the portion of excellence of the S & T system appears to be more naturally articulated toward a world scientific system. This may be due to a traditional quest and preference for a "universal" or "pure" science, as opposed to an "applied" science, the country's historic failure to link scientific research with the productive and economic processes, or various combinations of both. On the other hand, it may be part of a sort of internationalization trend perceived similarly in the economic system. In any case, as a member of this world system, a substantial fraction of the national S & T system's product tends to lose its "national" character and is in effect, ultimately directed at, and mostly consumable by, the world's scientific centers and their corresponding societies, located in the advanced countries. This fact poses a problem of deployment of scarce resources by influential scientists working on prestigious "international science" problems with no relation to national needs, as has been pointed out by Rahman (1975).

On a national scale, meanwhile, we have what we believe to be characteristic of underdeveloped areas of the world: marked disparities in all areas of human pursuit that stem not the least from a chronic, structural and systemic disassociation between scientific knowledge and social reality. Even when there are specific official policy directives, national scientific policies in the more important and well funded research units throughout the country, are not considered as important for the selection of research topics (Jimenez et al., 1989: 10). This basic disassociation, although not an uncommon problem among peripheral countries (Stolte-Heiskanen, 1985: 5—6), is however greatly aggravated in our societies.

How do scientists see their social function?

Science in Mexico is done primarily in public institutions. Approximately 90 % of research institutions are public. This amount is composed of 69 % academic institutions, and 21 % institutions directly belonging to the federal government (Jimenez, 1988: 36).

Modern science developed initially at the National University and other academic

centers. Following the tradition of European universities, the major concern of scientists in the natural sciences has been the expansion of knowledge for its own sake. They visualize their activity much as the old philosophers visualized theirs: the search for truth and the advancement of knowledge in the area of their expertise. Since they represent the oldest traditions in science, and some have national as well as international prestige, natural scientists doing basic research tend to be the leaders of opinion among the scientific community, and try to permeate their views throughout applied and social scientists, with some success. These views include the adoption of evaluation criteria stressing the publication of scientific results in international journals of excellence, giving much importance to the number of times they are cited in other scientists' work. To the extent that scientists seek the acceptance of only external evaluators, their work becomes alienated from the social context of their own country (see e.g. Stolte-Heiskanen, 1987: 12).

The cultivation of science is not quite acceptable as a cultural value worth of support by the Mexican society. Nor is science likely to recieve more support and recognition until it penetrates society more widely and becomes an acceptable value. The fact that national outstanding scientists publish only in a foreign language does not favor the penetration of science in society, hence precluding the scientific infrastructure from growing. Scientists in the forefront are inclined to believe it is a waste of time to publish in their mother tongue because the amount of potential readers diminishes. Although this is partially true, we see no other way of establishing science as part of the national culture than by diffusing it in the language known by the population at large.

Although the view of scientific work advocated by the "internationalists" may be valid and is acceptable in countries with an older scientific tradition, and properly developed economies, this may not be so in countries with great social and economic disparities.

In contrast, applied and social scientists tend to visualize their work as embedded within a social commitment. Social scientists go to a point of becoming actors of the desired change, and of developing methodology which makes explicit their involvement, such as in participative research. Still, there are some groups of applied scientists in the natural sciences who struggle to take part in the international scene of developed countries. Most of them play a peripheral role of minor importance for the interests of international scientific powers.

Concluding remarks

Science, understood as the organization of individuals with the sole objective of conducting research, is a relatively recent phenomenon in Mexico, as well as in the rest of Latin America (see Jimenez et al., 1988: 1). Despite its youth, science in Mexico already displays imbalances such as the one we describe next.

Many of the most influential scientists are doing research in topics considered "in good currency" by the international centers, publish in prestigious foreign journals, thus believing they are contributing to the enhancement of "frontier" knowledge. They are concerned with the lack of proper support for R & D, and make in this respect strong demands to the administration. But they do not seem very sensible of the contribution science and technology could make to improve the quality of life of the population, nor are they very conscious of the social responsibilities associated with the scientific profession. They are aware of the lack of social recognition S & T has in our context, but their major concern is in making society accept science as having intrinsic value in itself. Therefore, they seem to be alienated from both the contextual environment that supports their research, and the work of fellow scientists not connected with the scientific Meccas. They also tend to disregard the relevance applied research and technology may have within our national context.

Scientists doing "national" science are less

visible, more connected with the realities of the country (social and otherwise), and may not be publishing in foreign journals because their research topics are not of interest to international audiences. They are, therefore, less influential in the decision-making process that allocates funds for R & D. How to reduce the disparity between these two sets of valuable scientists?

The modernization trend of the current administration grants the S & T system an important role: to provide scientific and technological support for the modernization of the industry and services. However, as it has been pointed out previously, due to the economic crisis, the scientific infrastructure has been disregarded for the past ten years, and as a result some of the most prestigious and experienced scientists have migrated in and out of the country. Many talented college students have not gone into a scientific career due to the lack of both economic incentives and social recognition. How could the S & T system cope with the challenge of today?

Modernization, understood solely as the advancement of material well-being, must not be the objective of developing nations. Such an apparent rise in the standard of living brings about unwanted side effects that on many occassions cancel the positive benefits. One of the roles scientists may play in the modernization efforts of Mexico, is to thoroughly study the unwanted consequences of material development, in order to prevent society from committing the same errors advanced nations have run into along the path to material progress. Some unwanted side effects are of scientific and technological nature, others are related to the organization of society for the achievement of "development" goals. Therefore, all sciences have a share in this plan.

Needless to say we are referring to problems of industrial pollution, deterioration of the environment, the quality of water and air, depletion of non-renewable resources, and all the ecological problems endangering the harmonious coexistence of man and nature in general. On the other hand, problems of the quality of working life, labor organization, even profit sharing, the preservation of family life, appropriate child care, youth education, and the drug and alcohol addiction, are some of the major social concerns.

Scientists should take part in the study and solution of these problems, hence contributing to a healthier conception of development. The goal should be not merely to improve the material standard of living of society, but to actually enhance the quality of life of the community.

Finally, in order to alleviate in part the lack of economic resources, research centers in academic institutions have to look outwards and become involved in research and technological development congruent with the needs of both industry and society, provided they are properly reimbursed. With time, this will also aid toward the social acceptance of S & T activities. In addition, it may contribute to the realization by some scientists that their work does not have to be alienated from real problems, and in the medium to long range, may have some impact on society.

NOTES:

1. As we write these lines, final preparations are being made to hold the upcoming University Congress, a unique, university-wide critical forum on precisely the social function of the University, of Science and of Scientific Research in general. The paradox resides in that Mexican science, being of peripheral nature, has been aware of its social relevance since the time when there was practically no scientific infrastructure in the country.
2. Although with several definitions (for an excellent, general definition, see Theotonio Dos Santos' (1973: 51)), for our purposes "dependence" refers to the notion that the dynamics of industrial-technological innovation lie somewhere else. Multinationals depend on their R & D laboratories in their home-countries, and local firms depend on capital and intermediate good imports. "Late", for S & T purposes, refers to a progress-related lag with respect to advanced capitalism.
3. Most of our top scientists have been educated in foreign institutions. They cultivate "international" science in "good currency", dominated by the needs and fashions of advanced societies (Witker, 1979: 31). Although this "frontier" science has some contribution to the international advancement of knowledge, it is very frequently not related to the needs of our own societies.

4. These are the descendants of Spanish and Indian intermarriages, composing the vast majority of the population.
5. For example, Mexico gained independence from Spain in 1821. However, internal disputes were quite commonplace in the country until considerably later. In 1848, partly as a result of this lack of internal cohesion, Mexico lost over half of its territory to an expansionist United States.
6. Among others, the entire political structure is transformed from a dictatorship to a democratically elected, liberal government.

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