THE JOURNAL OF DEVELOPMENT STUDIES

SPECIAL ISSUE ON SCIENCE AND TECHNOLOGY IN DEVELOPMENT

VOLUME 9 **OCTOBER 1972** **No 1**

Published by
FRANK CASS & CO LTD
67 GREAT RUSSELL STREET LONDON WC1B 3BT

Social Determinants of Science Policy in Latin America

EXPLICIT SCIENCE POLICY AND IMPLICIT SCIENCE POLICY

*By Amilcar Herrera**

The incapacity of Latin American countries to use scientific and technological research as dynamic elements for social development is a consequence of the characteristics of the prevailing national projects (that is the model of society to which, directly or indirectly, the groups who until now have had political and economic power in most countries in the region have aspired). Unless these national plans are replaced by others which are more in accordance with the aspirations of the majority of the population, scientific research will continue to be no more than a cultural luxury for these societies. In recent years, however, several countries in Latin America have initiated revolutionary processes, which involve radical changes in national projects. The final break with a structure of underdevelopment in the countries of Latin America depends on the success of these movements, and on their effect on the rest of the region.

Since the Second World War, and particularly in the last two decades, there has been intense international activity to increase the scientific and technological capacity of developing countries. Much of this effort has come from international organizations of a political or financial kind: for example the United Nations, with its diverse programmes and *ad hoc* organizations; or, in Latin America, the Organization of American States, and the Interamerican Development Bank. But government and private organizations in the industrialized countries have also played a part, with technical assistance missions, exchange of researchers, scholarship schemes for graduates, and the like.

A great part of the effort to promote the development of science takes the form of direct aid to increase the capacity of national R. & D. systems. Typical of this type of aid are: donations and loans for scientific equipment, subsidies for research projects, missions of qualified personnel to train nations or to help formulate science policy and scholarships for further study abroad. In Latin America this type of aid has provided a significant amount of equipment for research centres, particularly in universities, and hundreds of Latin American researchers have furthered their studies in the most important scientific centres of the world, particularly the United States.

* Research Fellow at the Fundacion Bariloche, Buenos Aires.

Alongside this, in international organizations and generally in the more advanced countries, there has been a considerable effort to find ways of 'planning science'. This has not been a direct form of aid, but it has made a methodological contribution to the solution of problems of scientific development in the Third World. In the advanced countries, 'science planning' is an attempt to control and direct an existing and, generally speaking, efficient scientific and technological research system. The problem in developing countries, on the other hand, takes a different form: scientific and technological systems in these countries are very limited, sometimes almost non-existent and scientific activities are almost totally unconnected with national problems. Consequently the fundamental problem in developing countries is not so much to improve the efficiency of an existing mechanism, but to build new systems frequently starting from almost nothing. Nevertheless the planning methodologies which are being developed in advanced countries, although they are imperfect and need adaptation to new environmental conditions, could be of very considerable value.

Thus it may be said that in the last decades the developing countries have received considerable direct aid—equipment, technical assistance, and training of personnel, for the development of science and technology. And they have also had available to them an elaborate conceptual apparatus for directing science, which was practically unknown when the advanced countries entered the scientific and technological revolution at the end of last century, or (in the case of the Soviet Union) at the beginning of this century. Add to this the fact that science has become one of the most important elements of national prestige, because of spectacular successes in many fields of social activity, and it might appear that circumstances have rarely been more favourable for developing countries to get access to the instruments they need for building up a modern scientific society.

However, after more than three decades of sustained effort, what are the results? A cursory analysis indicates that, in general terms, there has been an almost complete failure. We will briefly examine the case of Latin America, which may without much doubt be generalized to the rest of the developing world.

Firstly, the purely quantitative aspects. In 1963 total investment in R. & D. in Latin America was approximately 200 million dollars, or 0·2 per cent of the G.N.P., and 0·7 dollars per inhabitant. These figures may be compared with data from some developed countries. In 1963 Holland invested approximately 240 million dollars in R. & D. Sweden somewhat more, and Canada approximately 400 million dollars. In other words, two countries with populations comparable to Chile, individually invested more in science and technology than all the countries of Latin America put together. In the developed countries the *per capita* R. & D. effort is 12 to 13 times higher than the average in Latin America.

Comparison of R. & D. investment in each country with its *per capita* G.N.P. is also revealing. The G.N.P. index may be taken as a measure of relative wealth of a country, and therefore its capacity to invest in areas with long and medium term effects on the economy. In Latin America the relative effort by different countries is very similar, in spite of great differences in *per capita* G.N.P. Argentina and Venezuela, for example, have *der capita* incomes of 800 and 850 dollars respectively and invest 0·2 per

cent of G.N.P. in R. & D. Brazil, Bolivia and Mexico with *per capita* incomes of 240, 160 and 470 dollars respectively also invest about 0·2 per cent of G.N.P. Other countries in the region invest between 0·1 and 0·15 of their G.N.P. in R. & D.

It is often argued, particularly in Latin American ruling circles, that the percentage invested in science and technology in countries is low simply because they are poor, and their *per capita* income is small. Although this might be a reasonable explanation for some countries in the region, it is not for others. For example, Argentina and Venezuela devote 0·2 of their G.N.P. to R. & D., while the Soviet Union, Japan and Israel, with *per capita* incomes of the same order, invest between 1·1 per cent (Israel) and 2·2 per cent (U.S.S.R.) of G.N.P. Also China, with much lower *per capita* income than any of the countries mentioned, invests approximately 1·5 per cent of its G.N.P. in science and technology.

However, the quantitative deficiencies of Latin American R. & D. are less serious than the fact that the R. & D. is unconnected to the social organization in which it is carried out. In the advanced countries, most R. & D. is on subjects which are connected directly or indirectly with national goals, like defence, social development, or prestige. Scientific development is reflected in the development of industrial and agricultural technology and, in general, in the growth of production. In Latin America, on the other hand, most scientific research is irrelevant to the basic problems of the region. This lack of a connection between the goals of scientific research and the needs of society is a characteristic of underdevelopment which is even more important than low rates of expenditure on research. The irrelevance of much scientific work in developing countries is widely acknowledged and hardly requires proof. We will give only a few illustrative examples.

Thus, in Latin America, in spite of the low density of population in relation to land available for agriculture, more than half the people are chronically undernourished. However, research in this field is, with few exceptions, insignificant.

After the Second World War, agricultural production increased in Latin America at a rate of 3·7 per cent annually (a *per capita* rate of increase of only 0·8 per cent). However, two-thirds of this increase was due to the use of new cultivatable land, and only one-third due to improved productivity (1·2 per cent). In Eastern and Western Europe, on the other hand, 80 per cent of the enormous increase in post-war agricultural production was due to improvement of land yield. In the United States the global increase in productivity was 25 per cent over a period when cultivatable land decreased by 18 per cent. Regarding livestock, the situation is even worse: with the exception of Argentina, Uruguay and Chile, yields of meat, milk and wool are extremely low, and have remained almost stagnant in recent years. As a result, livestock production increased in the region at a rate of 1·3 per cent per annum, a *per capita reduction* of 2 per cent.

In the industrial sector the situation is no better than in agricultural sector. Industrial technological research is practically non-existent. The private sector contributes only 3·5 per cent of the total R. & D. investment in Latin America, amounting to approximately 0·007 per cent of the regional G.N.P. And whereas in developed capitalist countries between 60 and 70 per cent of R. & D. is *undertaken* by the private sector (though some of this is *financed* by public funds) in Latin America the private sector under-

takes between 1 and 5 per cent. In Argentina, the relatively most industrialized country in the region, the private sector carries out only 2 per cent of the total R. & D. work in the country.

The pattern of R. & D. activities in Latin America also reflects the lack of social relevance. In advanced countries far more is invested in applied and development research than in basic research. The ratio of these expenditures is 9 to 1 in France, England and the United States and about 4 to 1 in the rest of Western Europe. In Latin America on the other hand, these ratios are more like 1 to 4 or 1 to 9. Although there is no precise data, it is estimated that much more is spent on *basic research* than on applied research and development. At the same time, because applied research is so weak, there is practically no interaction between the different types of research and between research and production. The few basic research centres of quality are generally closely connected with the scientific systems of great powers (both in the type of research they do and, in many cases, in the sources of funding they use). They function as isolated enclaves which do little to encourage local R. & D.

This picture of general stagnation is characteristic of all Latin American countries. However in addition, in several of the countries, scientific activity has been restricted further because many research centres (particularly in the universities) have been disbanded by governments of force established in recent years.

Thus, scientific and technological activities have stagnated and even regressed in spite of international efforts to build them up. In consequence, those who are responsible for programmes of international co-operation have become sceptical about the capacity of developing countries to solve their own development problems. There is a tendency to give funds preferentially for projects with 'direct social interest', like housing investments and health, instead of setting up programmes which would create the scientific and technological capacity to solve basic problems of which the visible manifestations are only a symptom.

However, this disappointment about the efficiency of aid has not led to any serious revision of the suppositions on which the aid programmes are based. It is generally supposed that the failures are not so much due to errors in the evaluation of the nature of the obstacles to be overcome, but simply to the fact that they have been underestimated.

In my view, however, the almost complete failure of international aid programmes is due to the fact that they are based on erroneous suppositions about the problem of incorporating science and technology in the production system in developing countries. The obstacles to this process are not 'passive', as is generally assumed. They are a direct consequence of the structure of underdevelopment which resulted from the insertion of the Latin American countries into the international system. In other words, scientific underdevelopment is not simply the result of some great lack or of some failure in the system which can be corrected with external aid; it is a consequence of economic and social structure. At this stage we will make a brief analysis of the factors which are commonly thought to account for scientific and technological underdevelopment in developing countries: in other words, the factors which are usually taken into account in working out aid programmes. Afterwards we will seek a more convincing explanation than they alone can give.

The obstacles to the development of science which are conventionally

considered, may be classified in three groups: (*a*) cultural obstacles; (*b*) obstacles connected with the production system; and (*c*) institutional obstacles.

(*a*) The term 'cultural' is used in two completely different senses. Firstly, in the etymologically strict sense, it means the values, habits and customs which characterize a society, and which are the result of historic evolution. Second, also sometimes included as cultural factors are things like the general standard of education in a society, which might be taken to 'measure' the degree of development of human resources.

In the first sense, contemporary societies are conventionally grouped into two general types: first the 'modern western societies', which include fairly vaguely, the peoples who were involved in the Industrial Revolution at the beginning of the eighteenth century. It is argued that a fundamental characteristic of these societies is that they are 'dynamic', not only because they have become accustomed to an atmosphere of continuous change but also because they consider that lack of change is tantamount to stagnation. For these societies science and technology are essential, as instruments for change. The rest of humanity, which in general includes the underdeveloped world, lives in so-called 'traditional societies'. These include a great diversity of cultures, in the anthropological sense, but they are all supposedly characterized by their desire to maintain traditions and resist change. The difficulty of incorporating science and technology in the social structure is, it is argued, a manifestation of an aversion to change.

Another cultural obstacle to the development of science and technology is poverty, and the limited development of human resources. According to some, this is the determining factor in underdevelopment generally. Harbison [*1963, p. 118*] has expressed this point of view in the following terms: 'The basic problem of most of the underdeveloped countries is not a poverty of natural resources but the underdevelopment of their human resources. Hence their first task must be to build up their human capital—in more human terms, to improve the education, skills and hopefulness, and thus the mental and physical health, of their men, women and children. . . . The way to start seems obvious and quite uncomplicated: build schools and launch a massive programme of primary and secondary education and technical training.' The author goes on to point out that in his opinion the main obstacles to the implementation of massive education programmes are the lack of financial resources, and lack of occupational opportunities for qualified personnel. In his own words: 'In any country, developed or underdeveloped, education may become socially malignant of its people do not have a chance and the incentive to use it.'

(*b*) The characteristics of the production system in underdeveloped countries are also said to hinder the creation of scientific and technological capacity. Generally, the production structure of an underdeveloped country is said to fit the following picture: the agricultural sector predominates; land is divided into very large and very small properties, and most production is for subsistence. The industrial sector includes local artisan workshops, and small factories, and foreign sector of technologically more advanced industries and greater volume of production. In this kind of production system, which is characterized by a very reduced market for industrial goods, *demand* for local scientific or technological capability is very limited. The foreign firms import technology from their headquarters abroad. The few 'modern' local industries import technology in bulk, in one go,

and do not adapt it to local needs, nor do they keep pace with international technological development.

Although it is often not made explicit, the underlying conception in this structural picture is the 'dualistic' model of underdevelopment. According to this model two sectors coexist: a 'traditional' agrarian sector which is socially, economically and technologically backward, a remnant of the feudal structure of power and landownership; and a 'modern' sector, which is predominantly urban, relatively industrialized, with social, and cultural codes like those in the developed countries. The expansion of the modern sector should slowly transform and absorb the traditional sector, until a modern, integrated society is formed. We will return to this conception, which has been questioned by a number of Latin American intellectuals, later on.

(*c*) The institutional obstacles are those which arise from organizational defects, from lack of resources, or from inefficiency of government or private organizations, directly or indirectly concerned with formulation and implementation of science policy. The faults attributed to these kinds of organization in developing countries are too well known to be reiterated here.

These types of 'obstacle' (cultural, the organization of production and institutional) are basically 'passive'. They are conceived as the consequences of certain deficiencies in developing as compared to developed countries: the lack of adaptability to the type of change which Western society has experienced over the last two centuries; the existence of an underdeveloped industrial structure, lacking the enterprising spirit characteristic of modern industry; and finally, the lack of an efficient bureacracy, with knowledge of the institutional requirements of modern science.

It is this conception of the causes of scientific and technological underdevelopment which conditions the international organizations. The idea is simply that these various deficiencies must be made good. If they can be, science will become a kind of input to the production system which, with a big enough push, will contribute to breaking the inertia of underdevelopment, and to making essentially static societies dynamic. The successful use of science by progressive elements in the society will have demonstration effects which will break down cultural barriers. For example, if the most progressive local enterprises can be induced to use technological research, possibly with aid from the State, this would have a catalytic effect and start a chain of transformations leading to a modern, competitive industry. Institutional deficiencies, although difficult to correct, can at least be diminished considerably in sectors related to scientific activity, by providing technical assistance on science planning and management. As far as this 'approach' is concerned, the mechanisms used until now (e.g. scholarships for formation of personnel, or financial support for construction of institutions and for equipment, advice on science policy), are by and large adequate. The problem is whether the analysis itself is adequate.

We may now examine just how far these factors give a relevant account of problems in the Latin American countries. First, it is necessary to bear in mind that there is considerable variation in the conventional indicators of development (like G.N.P. *per capita*, educational attainment and so forth) between the Latin American countries. Although there are some

basic elements of unity, which we will look into further on, these variations must be remembered in the following discussion.

First, the cultural elements. These are presumed hostile to linkage between science and technology and the related society. Here, it is as well to remember that Latin America, unlike some other developing regions in the world, is the produce of conquest, colonization and European *migration*. In some countries (like Uruguay and Argentina) the population is almost totally European in origin. But, even in those countries with a high percentage of indigenous population, the dominant classes and basic cultural patterns are also European. In certain Latin American circles there is much talk of an 'indigenous cultural heritage', which is either attacked (as being a factor in underdevelopment) or praised (on the presumption that the old values are worth conserving). This is not the time to analyse the underlying motivation for these 'indigenous' attitudes. However, I believe that they are mistaken, because at the present time there is, strictly speaking, no indigenous culture in the region, with the exception of some small localities which do not alter the general picture. Descendants of the inhabitants of Latin America before the conquest now constitute the peasant masses who do not own land and the 'marginalized' proletariat concentrated in the suburbs of the large cities. Culturally, they differ very little from the dispossessed masses which exist, or existed, in the Western countries.

The bourgeoisie who are in political and economic power in almost all the countries are not characteristically resistant to change, in the way that the ruling classes in the co-called 'traditional societies' are supposed to be. They are totally incorporated in European culture—where they have their origins—and their values and cultural codes are no different from those of the most sophisticated Western societies. When they resist change it is not because of a cultural inheritance; the roots of their resistance must be sought, as we will see later, in the desire to preserve with the minimum possible modification the socio-economic structure on which their privileges depend.

Moreover, recent history suggests that when a country breaks the socio-political structures of underdevelopment in any way, cultural heritage does not prevent the effective social use of modern instruments for development. The cases of Japan, the Soviet Union and China are sufficient to demonstrate the point. The last country was considered until recently a veritable paradigm of stagnation determined by a traditional culture. Yet now Harbison writes of China: 'Once a land of philosophers, artists, and peasants, China is being transformed into a nation of technocrats. Its Confucian sages have been replaced by scientists, engineers, and industrial managers. . . . In its universities the humanities have been downgraded, and more than 55 per cent of the students are enrolled in science and technology, compared with 25 per cent in most other countries.' Finally, we may recall that the Mexican revolution and the Bolivian revolution of 1953—which aimed to transform and modernize the most archaic structures in Latin America except for pre-Revolutionary Cuba—were staged mainly by sectors of the population of predominantly indigenous origin (Mexican peasants and Bolivian miners) and not by the presumably more dynamic and open-minded 'modern' sectors.

The scarcity of skilled human resources—another type of 'cultural' obstacle—has never really been a significant constraint, at least not

in the larger countries in the area. The fact that a good number of scientists and technologists emigrate from the region to more advanced countries because they cannot find employment within local scientific systems, suggests strongly that manpower is not a problem. Moreover, in modern historical experience, systematic and massive programmes to produce highly skilled personnel have never been a decisive factor in initiating innovation, but rather one of its consequences. An initial shortage of qualified manpower could delay the moment when the R. & D. system reaches 'critical size' but should not affect its rate of growth. Indeed, scientific systems in Latin America are characterized by stagnation rather than by inadequate size.

The limited demand for science and technology because of the structure of production is, without doubt, a most important explanatory factor. However, a brief look at the characteristics of the Latin American economies indicates, that the production structure cannot, by itself, explain the underdevelopment of science and technology. Here we can discuss some immediately relevant aspects since it is beyond our scope to make a detailed analysis of production in the region. We will look into the problems of agriculture later; first we refer to industry, where the problems facing scientific and technological research are easier to compare to those in industrialized countries.

It is true that in many Latin American countries the industrial structure is divided into a sector dominated by foreign capital, where practically all the 'modern' manufacturing units are located, as well as the enterprises which produce primary products for exports—and a 'local' sector, with small production units, many of which have been unable to rise above the craft stage. In some of the larger countries, however, there is a very different pattern. In Brazil, Argentina and Mexico particularly, a considerable proportion of industry, including some of the more dynamic sectors, is controlled by foreign capital, but the local sector is also large and accounts for a considerable part of the output of manufactured goods. Even here, however, the local sector undertakes almost no R. & D., and this has been attributed to the fact that it consists of small and medium-sized production units. It is argued that international experience has demonstrated that R. & D. can only be carried out by large enterprises of the multinational type, presumably because of problems of scale. However, European studies suggest that this may not be the case. A recent O.E.C.D. study of France says: 'As regards research, it is generally believed that medium and small enterprises cannot support large efforts, and that their competing position vis-à-vis large enterprises, is made more difficult in consequence. However, the 1963 survey reveals that small enterprises (less than 600 employees) are not always surpassed by large ones as far as the percentage of sales to research is concerned. In these firms, more than 16 per cent of the staff is involved in R. & D. whereas firms employing more than 1,250 appoint less than 6 per cent to this activity.' In another study, carried out in Belgium, the data 'tended to prove that "medium" enterprises (100 to 500 workers) are in no way excluded, by virtue of their size, from effective participation in creative scientific and technological activities . . . research is possible, profitable and efficient at this level. It is not very frequent, but the frequency can be, and should be multiplied' (*C.N.P.S., 1965*).

These remarks refer to the private sector only. To have a clear picture

the public sector must also be considered. In Argentina, for example, almost all infrastructural services belong to the public sector: railways, communications and electricity, as well as a large part of basic industry, such as petroleum, petrochemistry, iron and steel and shipbuilding. The situation is similar, although varying in degree, in other major Latin American countries. Almost all enterprises in the public sector are comparable in size to large enterprises in developed countries or, as in the case of the 'Yacimientos Petroliferos Fiscales' of Argentina, even comparable to large multinational corporations. It appears therefore that the production structure is not in itself sufficient explanation for scientific and technological underdevelopment, at least in the major countries of the region.

As far as institutional problems are concerned (inefficiency and organizational defects) it is arguable that they are no greater in Latin America than they were in countries which entered the Scientific Revolution in the nineteenth century. Moreover, these deficiences are never really significant in themselves; they are only significant to the extent that they reflect more profound tendencies in the society.

We have tried to suggest that it is a fundamental mistake to suppose that the obstacles to effective incorporation of science and technology in society are passive or that the lack of a coherent science policy is an important contributory factor. The fact is that underdeveloped countries *have* science policies with goals of their own. These goals are different to those which the aid-givers (amongst others) would like to see, and there is a strong tendency to resist modification. It is however, difficult to recognize the existence of these 'science policies' unless a distinction is made between explicit and implicit science policy. Explicit science policy is the official policy. It is expressed in laws and regulations and the statutes of bodies in charge of scientific planning; in development plans; and in governmental declarations. It is constituted by the explicit resolutions and rules which are commonly recognized as the science policy of the country. Implicit science policy is far more difficult to identify because, although it determines the real role of science in society, it has no formal structure; in essence it expresses the scientific and technological requirements of what we shall call the 'national project of each country.

These two science policies are not necessarily contradictory or divergent; and we shall indeed discuss cases where they converge. Divergence only becomes critical when there are contradictions of a certain type within the national project. This is the case in most underdeveloped countries.

Before we define the concept of 'national project' more precisely, and describe how it generates a science policy, we need to be clear about the concept of an implicit science policy. Essentially, this concept is based on the idea that modern science, with its enormous cost and the great social effort which it entails, only develops when there is some effective demand for it from society. Countries only invest between 1 and 3 per cent of their G.N.P. in science and technology—which is the proportion which developed countries currently invest in R. & D.—if they are fully aware of the potential benefits. Modern history confirms this argument. The first great social impulse to science arose from the demands of the Industrial Revolution. In the latter part of the nineteenth century, industry began to need technologies which were based on science. Science had not been neceessary to technological development hitherto. The second

great impetus—which began in the first quarter of this century, and which has been maintained and strengthened since the 'forties—originated in the technological requirements of the great powers because of military competition and industrial prestige, etc. These two stages of the science and technology revolution developed without an explicit science policy in the sense of our definition. They were the result of the pressure of social needs on the scientific system, reflected in diverse and non-institutional ways, which constitutes what we have defined as implicit science policy. Explicit science policies appear later, because of the need to create a structure and to institutionalize procedures, in order to achieve maximum returns.

The 'National Project' is the set of objectives (or model of the country), to which the social classes which have direct or indirect economic and political control aspire. The most important component of this definition is the set of concrete objectives, conceived by the élite who are capable of articulating and implementing them. This concept is not the same as what is generally termed 'national aspirations', or 'national ideal', if these terms are taken to represent the social ideal to which the community, or the majority of the community, aspires. This can only become a national project when it is actually adopted by the sector of society in power and therefore able to implement it.

There are some logical consequences of these definitions which are relevant to the rest of the analysis. The first is simply that whilst a country may not have an explicit science policy, it always has an implicit one, determined by the interaction of the social system at large and the science system. The second is perhaps less obvious. If the explicit, stated science policy is not a real reflection of the scientific and technical requirements of the 'national project', it is an artifact and will diverge from the implicit, unstated but real, science policy. Thirdly, if there is social consensus about the 'national project' (or even passive acceptance) there is generally no need for a divergence between explicit and implicit science policy, and explicit and implicit policies will converge. The need for a divergent explicit science policy arises when there is conflict about the national project. In these circumstances it can be tactically convenient for the élite to claim that it is using, or intends to use, science and technology for some generally accepted social good, even though it may be quite incapable of doing so because the economic and social order on which it depends prevents any such thing from happening. Thus—conversely—where there is a fundamental conflict about the objectives of development (or national project), explicit science policies may emerge which cannot be implemented and which are in contradiction with the real use of science in the society.

In developed capitalist countries (the U.S.A. and Western Europe) there is usually sufficient consensus about the prevailing national project for us to take it as being reasonably representative of the aspirations of the population, at least from the point of view of material objectives. In socialist countries there is a similar situation, although here the formulation of a national plan which is representative of the aspirations of the majority was only achieved through revolutions which radically altered socio-economic structures. In both cases also the degree of consensus attained means that the content of explicit science policy coincides more or less with the scientific and technological demands of the prevailing

national project. In other words, there are no deep contradictions in the planning system and in the direction of scientific effort.

The situation in underdeveloped countries—and in Latin America in particular—is very different. In general in these countries there is no consensus about 'national projects' which essentially embody the objectives of the ruling élite only. In consequence there can be, and is, a sharp divergence between explicit science policy (i.e. the apparent and stated objectives of the science and technology system) and implicit science policy (the way science is actually moulded by social requirements). We now examine the evolution of distinctive national projects in the Latin American countries. Afterwards we shall look at the way these national projects have affected science—and particularly at the contradictions between explicit and implicit science policies in the Latin American situation.

In most of the countries of Latin America, the 'national projects' which prevail originated in the post-colonial period (although they inherited much from colonial times). In the post-colonial period the insertion of those countries into the international system as peripheral dependent economies, was consolidated: exporting raw materials and importing manufactured goods from the large industrial centres. In these countries the articulation and stability of national projects rested basically on an alliance between the main local beneficiaries (land-owning oligarchies, exporters and importers, who have always directly or indirectly had economic and political power in the region) and the centres of world power.

The imposition and implementation of these schemes of development, in which external dependence and supremacy of certain local classes are complementary aspects in a single global structure, was not simple. The civil strife which characterized this period of organization in Latin America is a testimony to the vicissitudes of the process. These national projects were ultimately based on the extensive cultivation of land, on the exploitation of the main sources of raw materials by foreign enterprises, and on very limited industrialization to produce a few basic consumer goods. They generated almost no local scientific and technological demand though science may have been demanded as a cultural luxury or as a means of social 'maintenance' (e.g. medicine, or professional engineering). Consequently, there was no stimulus for development of technological research. There was a small amount of basic research mainly related to the few disciplines for which there was some social demand (such as medicine, in the more developed countries of the region). Alternatively basic research developed precariously in isolated nuclei, almost totally unrelated to the local environment, and deeply influenced by large scientific centres abroad.

This type of national project, in spite of its evident limitations, developed and was maintained without too many difficulties until the beginning of the century. The societies had inherited from their colonial past, a strongly polarized and rigid social structure, with a mainly urban ruling class, which almost totally dominated an interior, sparsely populated by illiterate peasants whose standard of living barely surpassed subsistence.

In the first decades of the century, however, there were changes in the international scene. These changes generated reactions internally in the countries of the region, which profoundly affected the viability of the model of development. The main changes were the Great Depression, which caused a drastic reduction in the demand of raw materials: the world

wars, which stopped the flow of manufactured goods to Latin America for long periods; and perhaps most decisive in the long term, the continuous deterioration of raw materials prices in relation to industrial prices. Simultaneously with the pressures generated by external factors, internal processes appeared or become more evident, which also modified the conditions on which the traditional plans were based. Among the most significant were: the demographic explosion; rapid urbanization, partly as a result of the migration of peasants to the cities; the growth of a middle class as a result of industrialization, expansion of services and the expansion of governmental bureaucracy; rapid growth of the industrial proletariat, particularly in the more advanced countries of the region; and finally, expansion of elementary education and mass communication, which brought new habits and values to sections of the population which had hitherto been isolated from any part in the process of social decision.

Consequently the Latin American countries faced a combination of new circumstances, which were characterized by an international economic system in which it was increasingly difficult to satisfy demand for manufactured goods by imports, together with increased pressure from large sectors of the population to take part in the political process. These new circumstances forced a modification of the type of national project which had been in existence. Industrialization started, based on import-substitution. This began during the First World War, and reached its height in the period between the Great Depression and the end of the Second World War. At the same time, in practically all of the countries the rapidly expanding middle class got access to political power. It would, however, be a mistake to assume that there was a direct correlation between the accession of the middle classes to political power, and industrialization. Claudio Veliz [*1965, p. 3*] discusses the characteristics of the new middle class, and its influence on the process of change. 'They formed parties of reform which, with very few exceptions, were predominantly urban, free-trading, liberal, radically anti-clerical and non-industrial. While in Europe a direct relationship existed between the growth of industry and the quest for reform in the nineteenth century, this was not so in Latin America where "industrial" reformism, imported from Europe, paradoxically preceded the coming of industry by almost a century. The Latin American parties of reform did not represent a manufacturing interest for the simple reason that there were no manufacturers important enough to constitute national pressure groups. . . . Hence, during the two decades following the Great Depression, industry came generally to Latin America not as the outcome of a deliberate policy of modernization on the part of a reformist urban middle class, or as the marginal consequence of the distinct way of living of a rising industrial class on the European model, but as the direct result of a *historical accident*.'

The full implementation of these modified national projects, centred on industrialization, would have required modifications in the social, economic and political structure. Full implementation supposed as a minimum a radical redistribution of income so as to create a mass-market. It also required changes in agriculture, notably the destruction of large holdings, and the introduction of modern methods; a break from external dependence, abandoning the limited role of raw material producers; and a complete restructuring of the State to give it the strength and authority to

nationalize production and to control the strategic elements of the economy.

These reforms, with a very few and limited exceptions, were not undertaken. The main reason is that they would have required an alliance between the middle class and the people, peasants and industrial workers, and inevitably the participation of the masses in political power. The middle class groups, afraid of unleashing a process which they would not be able to keep under control, preferred to share power with the old dominant classes and to attempt reforms rather than radical changes in the system. Consequently, middle class control over political power failed to produce a new integrated model for development. Moreover, the old dominant classes together with their foreign associates still controlled the key points of the economy, in spite of a partial loss of political power. As a result the old national projects prevailed as conceptual structures. The modifications which were introduced and the steps which were taken to protect and encourage industrialization, were generally looked upon as temporary measures designed to respond to emergency situations and to avoid the total collapse of the system.

The process which we have so briefly reviewed helps to explain contradictions in the science policy of the countries of Latin America. Such changes as took place in the national plans, required very little local R. & D. to begin with. Industrialization started with the replacement of easily manufactured products, and the required technology could be imported. As the process advanced, however, it became increasingly necessary to export non-traditional goods. More complex goods had to be produced, in areas where technology changes rapidly because of R. & D. carried out in developed countries. In these circumstances, the inability of local R. & D. to carry out original technological research, or even to adopt intelligently technologies developed abroad, was a contributory factor in declining international competitivity. Also, low productivity in agriculture and livestock production—largely the product of technological underdevelopment resulting from the landowning structure, was increasingly a problem: the more particularly because of growing internal demand for food due to rapid increase in population, increased local demands for raw material for industry, and the need to maintain agricultural exports so as to meet capital requirements for industrialization.

Thus, although the modifications introduced to national plans did not really alter their essential features, their viability depended on a radically different kind of science and technology input. It was in fact necessary to create a local R. &. D. system capable of efficient interaction with the production sector. However, the construction of an R. & D. system with these characteristics stumbled from the start. There were a complex variety of problems, but the essential contradiction arose from the fact that the middle class rose to power without being able to elaborate a true alternative to the prevailing traditional national project. Since the economic organization from which the old dominant groups derived their power remained practically untouched, they still had a decisive influence on the direction of national development. Their influence was either directly exercised, or expressed through their ideological and cultural control over a large part of the middle class, including the new industrial bourgeoisie.

This élite, partly because of its cultural background and partly because of its own interests, had neither the ability nor the desire to create an efficient R. & D. system. Their basic concepts of development required little

technology—and accordingly, they regarded scientific activity as a luxury, appropriate for the rich and advanced countries. The concept of science as an instrument, as a tool for change, met with deep-rooted prejudice. Moreover, since the élite was anxious to prolong the existing system as much as possible any change which might alter the precarious balance on which they depended was potentially dangerous. These two factors: the limited conception of the role of science in development in the perception of the old élite, and the wider lack of trust in any element of change, were the main obstacles to scientific progress in this stage of modification of the national project.

In summary, there was a basic contradiction because the full implementation of a programme of industrialization required a new type of social and political organization. But the social organization did not change fundamentally; the old system was held in place by a new alliance between the old élite and the middle class. A particular aspect of this situation was that whilst there was a definable need for local science and technology for industrial development, the social and political system effectively prevented the growth of science.

This was a phase of 'passive resistance' to science and technology. The élite was subconsciously indifferent to science and unaware of its potential rather than deliberately concerned to hinder or subordinate scientific progress. Eventually, however, this gave place to a new state of affairs, in which science and technology has a more significant role—but which is characterized by profound contradiction between explicit and implicit science policy. There are two main reasons for the shift in emphasis: (*a*) continuous economic and social deterioration in the countries of the region, which made it increasingly clear that, in spite of modifications, the limits of the traditional national project had been reached; (*b*) increased awareness on the part of those benefiting from the *status quo* of the revolutionary potential of science in the Latin American environment. We will attempt to explain, although very sketchily, how these two conditions interact.

The deterioration of the socio-economic situation, and growing popular pressure, have generated two, complementary, responses from the oligarchies. First, there has been an attempt to strengthen the apparatus of political dominance—the most conspicuous examples being the appearance of politically autocratic and economically liberal military governments. Second, there has been an attempt to correct the more glaring faults in the system to avoid its total collapse. In this context, science has come to have a double role: in the first place it is used as a prestigious façade by 'progressive' or 'modernizing' governments. Second, it is used as a tool, to solve urgent material problems, but it is also presented as a panacea, capable of curing the ills of underdevelopment, without necessitating changes in the system.

In this way policies of formal support for science have made their appearance, characterized by regulations and laws to encourage scientific activity, requests for co-operation from international organizations, continuous verbal praise of the value of science as a vehicle for development, and above all, the creation of organizations to manage and to plan science (National Councils of Scientific Research, for example) whose statutes and structures are very like those of similar organizations in the developed countries. Essentially, all this constitutes the front, mainly formal and declarative which we have called explicit science policy.

But the real science policy—implicit science policy—is very different from this brilliant front. The objective of the ruling classes is not to create R. & D. systems which will make the countries scientifically autonomous. This, apart from being unnecessary to the social organization they wish to maintain, could actually endanger the national projects which they seek to prolong. Their objectives are mainly to create a scientific and technological system which will help to solve minor problems without putting the system itself in question. It has become apparent, however, that it is extremely difficult to circumscribe scientific activity in this very rigid manner. The more or less autonomous scientific centres, particularly in universities, tend to become discussion centres where the fundamental values of prevailing order are questioned. The political leadership does not realize that this critical or 'subversive' attitude—to use the stereotyped official terminology—has its origins in free discussion of ideas in an atmosphere of scientific objectivity. They become alarmed because they cannot tolerate serious analysis of the system. Consequently they try to neutralize criticism by repressing free expression, by ideological persecution, by selecting scholars for their ideology rather than for their intellectual ability, and so on. The result is that the scientific structure, submitted to a régime which is incompatible with genuine intellectual creation, is degraded, until it becomes incapable of satisfying even the limited demand of an essentially static system which only aspires to maintain itself.

Dr Francisco de Venanzi, President of the tenth Congress on Physiological Sciences summarized the position: 'A large proportion of scientists (from Latin America) is submitted to political presecution, most of them to serious economic restrictions, and almost all of them are discouraged by the environment to keep up their scientific activity' (*La Opinion*, Buenos Aires, July 14, 1971).

Contradictions between explicit and implicit science policy are evident therefore, when there is a crisis about the national project; in other words, when the social group which created it still holds most of the political and economic power, but has lost the consensus or more accurately the passive approval of the rest of society.

A brief analysis of what happens in the agricultural and industrial sectors may help to illustrate the divergence between explicit science policy and the realities. The most important characteristic of Latin American agriculture is the concentration of land in the hands of a few. According to J. Chonchol [*1965, p. 84*]: '. . . in Latin America there are 105,000 agricultural and stockbreeding holdings of more than 1,000 hectares each representing 1·4 per cent of all holdings and covering 470 million hectares, or 65 per cent of the total included in the agricultural and stockbreeding land rolls. This gives an average of 4,500 hectares for each of thees holdings. . . . At the other extreme, there are 5,445,000 holdings, constituting 72·6 per cent of the total, with less than 20 hectares each and occupying 27 million hectares, that is 3·7 per cent of the total included in the rolls. This gives an average of less than 5 hectares for each of these holdings.' Finally, 'of the 111 million rural inhabitants in 1960 and the 30-odd million making up the economically active agricultural population, only some 100,000—and these are probably largely urban and non-rural residents—own 65 per cent of the total agricultural land of the region. In discussing the social consequences of this landowning structure the same author says: 'land concentration gives rise to a very unequal distribution of agricul-

tural income which is also—on average—well below the income obtainable in other sectors of the economy. This, in concrete terms, implies a state of sub-human living conditions for the majority of the population in the countryside. About one-third of the population of Latin America lives in abject poverty' [*Chonchol., 1965, pp. 81–82*]. Because land ownership is the main source of power and social prestige, the tendency to accumulate property is a constant feature of the system. Citing J. Chonchol once again: 'Everything, indeed, tends to accentuate the desire and urge to accumulate land which, by virtue of the political influence of the owners, pays only a minimum in the way of taxation, and tends to maintain a high real value in the midst of the continuous monetary devaluation process in many of the Latin American countries. In addition, this system results in the land remaining as natural pasture or being subjected to a minimum of agricultural use: its value is greater as a source of personal income, social prestige, and political power than as a factor of agricultural production.'

These basic characteristics of the agrarian structure help to explain resistance to technological development. In the first place, the availability of great expanses of land and abundant labour enable the owner to reap sufficient benefit for purposes of personal prestige and power, with very little effort or capital. He does not need to introduce technological improvements—which always involve more capital—because the profitability of exploitation is based on extensive use of land and cheap labour.

The survival of the system, on the other hand, requires the rural population to be kept at the lowest possible standard of living, without organization, so that they have no alternative but to sell their services at the imposed price. One way of achieving this objective is to restrict educational opportunities, and this helps to explain why a high rate of illiteracy is so typical of rural areas in Latin America. Moreover, the underdevelopment of the rural areas is maintained because landowners, who usually live in the cities or abroad, invest their profits outside the rural sector, in luxurious property, in import/export businesses, or, to a lesser extent, in industries which satisfy the demands of the high-income urban classes. Consequently, the urban sector bases its prosperity, to a large extent, on the exploitation of the rural population. We are not dealing with a 'dual society', in which the rural community is gradually brought into the 'modern' sector, but with a dynamic structure of underdevelopment in which the prosperity of the 'modern' sector depends on the depredation of the so called 'traditional' sector [*e.g. Garcia, 1970*].

Mechanization of production, introduced in recent years in some holdings in the region, does not substantially alter the picture. These are not improvements based on a scientific study of the requirements of the agricultural sector as a whole. They involve the mechanization of some large holdings, usually producing for export, and are instances of 'isolated modernization' which is not based on technological research and which does not generate further research. The remainder of the agricultural sector continues in a state of misery and ignorance.

The retarding effect of the agrarian structure in Latin America is not limited to the rural area: its effects on the rest of the economy have been synthesized by Zimmerman [*1966*]: 'in none of the poor countries (predominantly agrarian) are the rich [landowners] in favour of economic development. Economic development, in the long term, would inevitably

lead to increased demand for work (industrial), and, therefore, to a reduction in unemployment (disguised) and to increased salaries. In the long run, as a result, an increase in the land–man proportion would occur and therefore a reduction in the profitability of the land. Add to this fact that taxes (direct) increase with the increase in *per capita* income, and you have sufficient evidence to understand why rich landowners are not in favour of industrialization.'

Resistance to the incorporation of modern technology is, therefore, an intrinsic characteristic of Latin American agriculture. This resistance is a natural outcome of the predominant national project. The dominant classes know that technological development cannot be introduced merely as an isolated input to production; but is part of a global process, which once started is very difficult to stop, and which endangers the stability of the social structure on which their privileges are based.

The process of industrialization in Latin America involves more complex social relations than in the agricultural sector. The predominance of the traditional classes has been almost total in agriculture, whereas industrial development was the arena for a variety of political and social forces. The supremacy of the traditional forces was not complete, and although the newer social forces in general did not have the capacity to oppose a true alternative to the prevailing national project, they introduced, willy nilly, new concepts and objectives. They created a pattern of industrialization which after an initial period during which market conditions were very favourable, could only be maintained by heavy protection, but which, if destroyed, would bring about socio-economic chaos. Faced with this paradox, policies for industrial promotion were limited mainly to imposing customs restrictions without any accompanying effort to create a capacity for technological innovation.

The underlying reason for this lack of clear plans and objectives lies in the attitude of the traditional classes. Generally, the old élite or their representatives in government took whatever opportunities were offered to delay the process of industrialization. Aldo Ferrer, an Argentinian economist, analysed the economic policies in the country after 1955 (when a military coup deposed the government of Peron) as follows: 'If one takes note of those who have gained and those who have been adversely affected, the origin of the coup becomes clearer. There has been a transfer of income from the rest of the national economy to the agrarian sector and an increase in the returns on capital and enterprise in this sector. Also while the value of land has rapidly increased in recent times, industrial shares have fallen considerably, reflecting, by and large, a process of elimination. It is obvious that the origin and the inspiration of this policy must be found in the sector around which the historic evolution of the country has gravitated; the large landowners in the pampa. . . . In the last instance, the intention is to dismantle the industrial sector, and to put the economy once again on the basis it had as a primarily exporting economy. In other words, to return the exporting sector to the key role in Argentinian development' [*Ferrer, 1963, p. 235*].

Nevertheless, the chronic disequilibrium in foreign trade, together with the social changes up already described (population explosion, rapid urbanization, etc.) have meant that industrialization is irreversible. To sustain economic growth it has been necessary to keep broadening basic and capital goods industrialization. The most significant difficulty in maintaining

this process has been the shortage of capital in the region. There are two alternative ways to meet the problem:

(*a*) The construction of basic industries by direct State intervention, since the State alone has the capability to resolve the financial and technical scarcities in the region; or,

(*b*) to bring in foreign investment, with the attendant risk of denationalizing the economy.

The first alternative (direct state intervention) directly or indirectly implies the socialization of the economy; it also poses a serious threat to the land-owning oligarchies, because capitalization must involve reducing the profits of exporters who have always enjoyed tax concessions. It is therefore, not surprising that the traditional classes in Latin America, and their allies, opted for the foreign investment alternative. In this way the old alliance between the Latin American oligarchies, and the power centres of the world was continued in a new form—involving dependence on multinational business.

This process of economic denationalization is not easy, because there is generally resistance by the majority of the population. In order to carry the policy through it is more and more necessary to use political oppression. In a sense therefore, the results which have been achieved are a testimony to the amount of power which the old traditional classes still retain. Aldo Ferrer, this time as Argentinian Minister for the Economy, at a session of the Interamerican Committee of the Alliance for Progress, described the economic evolution of the country in recent years: 'the Argentinian production and financial systems reveal an alarming degree of denationalization. Of the ten largest manufacturing enterprises, eight are based on foreign capital, and the other two are state enterprises. The financial scene is similar. Approximately 50 per cent of private banks are foreign, and the rate of participation has increased with time. It is a significant fact that most of this denationalization in strategic sectors has been financed by internal credit, or by external credits guaranteed by the Argentinian State.'

The effect of this type of development on local scientific-technological systems is well known. In the first place, the part of industry which is dominated by foreign capital generally includes manufacture of science-intensive capital goods. But all the research is done at the headquarters of the foreign enterprises. Local 'research' is concerned with routine tasks like product control and materials testing.

An indirect but important effect of this policy is that it generally meets with opposition from the autonomous research centres, particularly in universities. It is no coincidence that denationalization of the Argentinian economy should have been accompanied (in 1966) by the virtual destruction of those university centres which were most aware of the capacity of the country to attain scientific and technical autonomy, and by the progressive reduction of State contributions to universities for scientific research.

REFERENCES

Chonchol, J., 1965. 'Land Tenure and Development in Latin America' in Veliz [*1965*].
C.N.P.S., 1965, *Recherche et Croissance Economique*, Vol. I, Brussells: Conseil National de la Politique Scientifique.
Ferrer, A., 1963, *La Economia Argentina, las Etapas de si Desarrollo y Problemas*, Mexico: Fondo de Cultura Economica.
Garcia, Antonio, 1970, *La Estructura del Atraso en America Latina*, Buenos Aires: Palmar.
Harbison, F., 1963, 'Education for Development' in *Technology and Economic Development*, London: Penguin.
Veliz, C., 1965, *Obstacles to Change in Latin America*, London: Oxford University Press.
Zimmemman, L. J., 1966, *Paises Pobres, Paises Ricos*, Mexico: Siglo XX Editores.