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TECHNOLOGICAL CHANGE, ECONOMIC DEVELOPMENT AND INTRA AND EXTRA REGIONAL RELATIONS IN LATIN AMERICA

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PREFACE

This monograph has been prepared with the aim of offering a summary of the results of the IDB/ECLA Science and Technology Research Program, whose first research period ends in December, 1978, after three and a half years in operation. The paper also includes some reflections on these results.

The Program's main aim has been to study the flow of domestic technological efforts, its causes and its micro and macroeconomic consequences, in various branches of manufacturing in five Latin American countries: Argentina, Brasil, Colombia, Peru and Mexico. The sectors studied include the following: 1. Iron and Steel, 2.the Tobacco industry, 3. the Construction and Building industry, 4. petrochemical and rayon production, 5. the petroleum distillation sector, etc.

The Program has published almost 30 working monographs during the first phase of its operation. This document is the first attempt to summarize some of the most interesting results obtained in the field of the theory of technological change in relatively less developed countries and of the relation between that theory and the study of Latin American economic development.

The paper is divided into four chapters. The first one presents a brief overview of the development of the theory of innovation, an area of analysis to which the various lines of research undertaken by the IDB/ECLA Program naturally belong, It seems clear that the theory is gradually moving towards an analysis of the microeconomic aspects of innovative behavior, a subject which so far has been accorded relatively little importance because of the "exogenous" character attributed to the technological variable in the economic growth theories developed during the 1950's and 1960's.

The second chapter argues that most recent literature in this field attempts to describe the microeconomic aspects of innovation and technological change in developed countries, and that in fact so far we know very little indeed about the technological behavior of firms operating in relatively less developed countries. It seems clear that various Latin American countries - particularly Argentina, Brazil and Mexico, and to a somewhat lesser extent Colombia, Chile and others - are at the moment moving along a particular path of modernization and technological change, the features of which have scarcely been researched by economists. The study of these topics must undoubtedly be given priority if we aim to throw any light upon the development path of the Latin American region.

The third chapter is intended to evaluate the extent and nature of local technological activity undertaken by various firms and branches of industry in the countries covered by the different studies. After presenting some quantitative indicators which give an approximate idea of the extent of the technological activity observed, this chapter examines the following topics: a. type of technological efforts undertaken; b. micro and macroeconomic variables which affect the amount and nature of local innovative activities; c. effects of local technological knowledge creation on the economic performance - both domestic and international - of the firms which generate it. During the course of this chapter various results obtained in the research projects of the IDB/ECLA Program are quoted; they demonstrate that it is impossible to attain an accurate description of Latin American development and of the current intra-regional balance between relatively more and relatively less developed countries, if we lack an adequate analysis of the role played by technological variables.

Although the overall progress we have made with regard to establishing the extent and nature of the flow of domestic technological efforts observable in various areas of production in several Latin American countries is significant, we are not so far in a position to state whether or not the efforts in this direction and the employment of skilled human resources involved constitute an efficient allocation of resources.

This query opens up a set of new questions which will have to be tackled in future research into technological problems. The third chapter concludes with a brief consideration of this subject and of the kind of future studies it would be necessary to undertake in order to analyse the topic in greater detail. In the final pages of the monograph we refer briefly to possible overall areas of action regarding technological policy and point out that in order to formulate such a policy it would be necessary to have studied a number of topics and be able to carry out a range of activities going significantly beyond the field which has been the main interest and focus of research of the IDB/ECLA Program. This must be borne in mind in order to place the results obtained in their proper perspective.

I. INTRODUCTION

Development theory has not man ged satisfactorily to incorporate the subject of technological change. For many years it has been treated as a variable outside the economic system, as a piece of technical data, concerning which the economist had little or nothing to say. Only recently has the possibility begun to be admitted that the rate, nature (bias towards relative saving of capital or labor), etc. of the technological change incorporated into a specific society may be determined by the general functioning of the economy. 1/

For economic theory to develop in this direction, it has been necessary for there to be a gradual but significant shift away from the neoclassical theory by which technological change reaches the firm free of costs, as if it were "manna" from heaven. In 1962 K. Arrow established the basis for a new approach to the technological phenomenon, when he argued that the production experience accumulated by the firm constitutes a new asset which the firm "produces" pari passu with its day-to-day activities. Arrow's conceptual counterpart on the empirical side can be found in the various studies of "learning curves" carried out by W.Z. Hirsh 2/, H.Asher 3/ and others.

However, the "learning by doing" theory contains nothing which would make us think that the firm has an explicit technological strategy. On the contrary this theory describes the research and development process as if it were a by-product of routine productive activity, as a benefit which the firm simply collects without incurring direct cost.

1/ The book by J.Schmookler, Invention and Economic Growth, MIT Press 1962, the NBER Conference on factors determining reaserch and development activity - see, Ed.R.Nelson: The Rate and Direction of Inventive Activity, Princeton 1962 - and K. Arrow's article of the same year - On the economic implications of learning by doing, Review of Economic Studies, June 1962, mark an important change of attitude within the profession in connection with the subject of technology.

2/ W.Z. Hirsh: Firm progress ratios. Econométrica, April 1963.

3/ H. Asher: Cost-quantity relationships in the air frame industry. The Rand Co. Monografía R-291, July 1956.

Only a decade later, and after the contributions of J. Stiglitz and A.B. Atkinson, 4/ W. Nordhaus, 5/ R. Nelson and S. Winter, 6/ H. Binswagner, 7/ P. David, 8/ N. Rosenberg 9/ and others, the profession is opening up a new path in the analysis of the technological phenomenon, much more realistic than that inherited from traditional theory.

Whereas the latter has its origin in the neoclassical debate on income distribution 10/ and thus does not arise from a real concern with the microeconomic features of innovative behavior, the new direction which the theory has followed in recent years is specifically rooted in the study of the microeconomic factors which determine technological behavior.

4/ J. Stiglitz y A.B. Atkinson: A new view on technical change. Economic Journal, September 1969.

5/ W. Nordhaus: Some skeptical thoughts on the theory of induced innovations. Quarterly Journal of Economics, 1973.

6/ R. Nelson y S. Winter: In search of useful theory of innovation. Research Policy, 1977.

7/ H. Binswagner: A microeconomic approach to induced innovation. Economic Journal, December 1974.

8/ P. David: Technological choice, Innovation and Economic Growth. Cambridge University Press, 1975.

9/ N. Rosenberg: Perspectives on technology. Cambridge University Press, 1976.

10/ Sir J. Hicks'statement in his Theory of Wages that the gradual increase in the relative cost of labor would lead the manufacturer to seek labor- saving technology was to trigger a complex debate in which W.E.G. Salter, Ch.Kennedy, W.Fellner, P. Samuelson and others participated. Hicks says (Theory of Wages, 1932, p. 124). "The real reason for the predominance of labor-saving innovations must be sought in the fact that a change in the relative factor price will encourage a particular kind of invention, intended to economize on use of the factor which has become dearer". The reply to Hicks given by Salter (see following note) opens debate which has not been particularly fruitful as far as throwing light on innovative theory is concerned. The situation has changed radically during the present decade in which the search has turned more towards the study of microeconomic behavior.

Unlike the traditional model in which technological change is defined as a "major" shift of the overall production function, in which it is necessary to introduce a frequently artificial distinction between shifts of the function as such and movements along it (the latter defined as factor substitution and described as different from technological change), 11/ in the new theoretical framework the concept of "minor" and "localized" technological change includes practically any non-trivial modification in the engineering and management rules followed by a specific productive unit, quite apart from whether or not they are novel at the level of the industry in which the firm operates. 12/

Within this analytical framework the way is quickly opened up for the study of the microeconomic behavior of the manufacturer who from one period to another is faced with the dilemma of whether or not to allocate resources to the "production" of new technological knowledge which may have one (or more) of the following objectives: (a) to reduce production costs by saving capital, labor, energy, substituting cheaper for relatively more expensive raw materials, etc.; (b) to improve the quality of the product in question; (c) to diversify the marketed output mix; (d) to eliminate bottlenecks which prevent increases in the physical volume of production, etc.

We have observed that it is no longer relative factor price (as in Sir J. Hicks' original view), or the relative weight of ca-

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11/ W.E.G. Salter, when making a critique of Sir J.Hicks' statements, writes: "If one takes Hicks' argument to mean that new labor-saving technical designs will be obtained from the existing stock of knowledge, then this is nothing more than factor substitution. It is merely a semantic difference whether we call this kind of new techniques "inventions" or "substitution of capital for labor". On the other hand, if the theory implies that the increase in the relative cost of labor will lead to a search for new knowledge which economizes on this factor, then this theory is subject to serious objections, since the manufacturer is interested in reducing his total cost and not the specific cost of one or another factor. Productivity and Technical Change, Cambridge, 1960, p.43.

12/ In the words of R. Nelson and S. Winter: "Practically any non-trivial change in a process or product, if there has been no previous experience, is an innovation". This sentence comes from the paper: In search of a useful theory of innovation. Research Policy, Vol. 6, 1977, p. 48.

pital and labor in total production cost (as in Ch. Kennedy and other authors who took part in the recent debate), 13/ which determine the technological expenditure strategy of a particular manufacturer. Other variables must also be taken into consideration; such as : a) the productivity and, b) the cost, of the possible alternative "technological search" strategies, and also c) the scale of production at which the manufacturer in question operates. Taken together these variables will determine both the overall extent of the technological efforts the manufacturer decides to undertake, and the internal allocation of these efforts among the several possible options.

In other words, contemporary research is moving towards the study of the factors which determine the alternative profitability of the different technological strategies available to a specific firm at a point in time, quite independently of whether or not the technological efforts it undertakes are novel worldwide, or of whether they shift the overall isoquant or merely constitute a "localized" improvement which affects one particular technique.

Now, the available theory based on this reconceptualization of the technological phenomenon so far refers to developed countries in which it is reasonable to assume that there is a systematic flow of scientific and technological developments which are subsequently absorbed by the various productive sectors and constitute one of the main factors determining the rate and nature of the economic growth process achieved by these sectors, and the specific position of these countries and sectors on the international trade, 14/ political 15/ and cultural scene.

13/ See: Ch. Kennedy: Induced bias in innovation and the theory of distribution. Economic Journal, September 1964.

14/ The papers by R. Vernon, G.Hufbauer, etc. within the framework of the "product cycle" and the so-called "neotechnology theory of trade" theories are the most interesting contributions on this subject. See: R. Vernon (Ed.) The technology factor in international trade. NBER, Princeton 1970.

15/ See, for example T. Dixon Long: Technology and power. Japan Catches up. In: Japan: the paradox of progress- Yale University Press, 1976 (Ed.) Lewin Austin.

Unlike the case of the advanced countries, the technological problem of the so-called "developing countries" has remained a practically unexplored territory which still requires both a systematic empirical research effort and an interpretative theory. The aim of the latter should be to gradually build up the micro and macroeconomic elements of a theory of innovation and technological change which would serve to throw some light on the situation of countries which, although not on the world scientific and technological frontier, nor the source of a flow of new technological knowledge of the magnitude of that which comes from the developed nations, must nevertheless be visualized as moving along a particular technological modernization path of their own, the specific features of which are still unknown to economists.

To build up such a theory of technological change for relatively less developed countries is not, however, a simple task. The first difficulty lies precisely in the heterogeneous nature of the kind of situations involved in the very concept of "developing countries". Within this overall concept there is such a wide range of developmental stages that it is practically impossible to imagine a single interpretative framework.

Let us look, for example, at the situation in Latin America. It seems clear that three countries in the region - Argentina, Brazil and Mexico - reflect a different typology with regard to technology from the remaining nations in the area. It is undeniable that in terms of industrial modernization and technological maturity these countries have reached a position which sets them apart from the rest of the region. Even though other countries, for example Venezuela, Colombia or Chile, are undergoing similar experiences with a certain time-lag, the sparse available empirical evidence suggests that the technological gap between the two groups is still considerable and, even more important, that that gap cannot be expected to be closed in the immediate future. Moreover, taken along with other variables, this growing technological maturity is gradually giving rise to a new set of situations on the Latin American scene, such as: a) the export of manufactures of considerable technological complexity (examples range from vehicles and machinery to antibiotics and include iron and steel, chemical and electronic products, etc b) the sale of technology through licenses, complete "turnkey" plants, etc. c) direct investment, d) technical assistance in the development of basic infrastructure projects, such as atomic energy, road, air and port networks, etc. Overall, these new technological and trade developments reveal an incipient form of intra-regional "internationalization" practically unknown until quite recently in Latin America

Recent studies of other so-called "newly industrialized countries" (NICS) show situations with a certain degree of similarity; among them India, Korea, Taiwan, etc. are the protagonists in a process of gradual technological maturation which is turning them increasingly into suppliers of manufactures and technology in various international markets. 16/

In our opinion, it is a matter of urgency to examine and understand these topics - and their technological background- since the gradual strengthening of the international position of the NICS would seem to be the rule rather than the exception in future decades. A new Latin American and world scenario would appear to be in the process of formation, and, in our opinion, the intra-regional transfer of technology and the local generation of local technological knowledge are focal points of this scenario and therefore demand further study.

The following pages contain some initial reflections on the subjects we have sketched out. They take up some of the results obtained by the different studies on innovative behavior carried out within the framework of the IDB/ECLA Science and Technology Research Program in various branches of manufacturing in five Latin American countries: Argentina, Brazil, Mexico, Peru and Colombia.

We begin by examining one of the topics mentioned in the foregoing paragraphs, that is, the relationship between stages of development and the extent and direction of domestic technological efforts detected in different Latin American countries.

16/ Regarding the Indian case, it is worth while bearing in mind the recent paper by S. Hall: Developing countries as exporters of technology. A preliminary analysis. Paper given at the "Workshop on International Economic Development and Resource Transfer" University of Kiel, June 1978 (Mimeo); while B. Cohen in his book Multinational firms and Asian exports (Yale University Press, New Haven 1976) examines the same subject with reference to Korea, Singapore and Taiwan.

II. STAGES IN DEVELOPMENT, TECHNOLOGICAL CHANGE AND DOMESTIC RESEARCH AND DEVELOPMENT EFFORTS

Even at the risk of introducing an arbitrary element into the analysis, it seems advisable to begin by distinguishing at least two different typologies with regard to the process of modernization and technological change in the group of "developing countries".

On the one hand, we find a group of countries with an intermediate level of development to which the literature of recent years has given the name "late" or "new industrializers". 17/ On the other hand, we have a residual category which brings together the majority of the underdeveloped countries - several in Latin America and most of the African and Asian nations - in which the process of modernization and technological change is the exception rather than the rule, and in which the greater part of society must characterized as participating in a developmental stage several decades behind both the industrialized world and the developed sectors of the nations of the first subgroup mentioned. 18/

17/ A. Hirschman, in a 1968 paper, The Political economy of import substitution, Quarterly Journal of Economics, February 1968, was the first author to begin to use the denomination "late late comers" to refer to Brazil and to distinguish this industrial development process from that which had several decades earlier characterised Germany, Japan and the URSS, which were themselves "late comers" with respect to Great Britain and the USA.

18/ It seems clear that within the group of "late industrializers" it is possible to find two quite different models. The first, typically prevailing in Latin America, is that of import substitution within protected enclaves, which after several years have begun to demonstrate a certain international competitiveness in manufacturing products and technology. Brazil, Mexico, etc. are examples. The second group, represented by countries like Korea, Taiwan, etc. reflects the early and non-subsidized development of a strong competitive capacity in industrial manufactures. As far as the empirical evidence goes, it seems clear that in both situations an increasing domestic technological capacity has been developing pari passu with the growth of the industrial sector. This domestic technological capacity is the real subject of analysis in this paper.

Within Latin America, Argentina, Brazil and Mexico - even in spite of the profound differences which separate them in many respects- must be considered as typical examples of "late industrialization". Outside the region, Spain and Greece or various Eastern European countries, such as Yugoslavia and Poland, among others, are examples which come to mind. Finally, Korea, Taiwan and Singapore also share various features of the "late industrialization" model, although they really correspond to a different industrialization strategy from the previously mentioned countries.

Unlike what happens in developed countries, a great deal of the process of modernization and technological change occurring in "developing" countries is a phenomenon involving the imitation of events which occurred several years previously in more advanced communities. The incorporation of these technological changes frequently requires the granting of subsidies to both domestic and foreign capital and is normally based on the transfer of products and production processes from abroad. Generally the opening of new branches of industry also involves- even in the case of countries with centrally planned economies, as we have recently had the opportunity to observe - the entry of multinational firms, engineering firms and financial agents from the developed world.

Since this situation tends to occur across the spectrum of economic activities, 19/ and is associated with transactions which take place in extremely imperfect markets, 20/ it is hardly surprising that the process of modernization and technological change in developing countries is often associated with the generation and outflow of an oligopolic rent which is captured by economic agents

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19/ Approximately 2/3 of the two hundred largest industrial firms in Argentina were operating at the beginning of this decade with one or more licensing contracts signed with international suppliers of technology and production equipment. See in this connection: J. Katz, "Importación de tecnología, aprendizaje e industrialización dependiente", Fondo de Cultura, Mexico 1976.

20/ The studies by C. Vaitsos and several other Latin American researchers have thrown some light on the highly imperfect nature of the markets for technology. The following book by the above-mentioned author can be consulted: Intercountry income distribution and transnational enterprises, Oxford University Press, 1974

of the more developed societies.

Up to this point in the argument - that is, during the technological acquisition phase- there are few differences to be found between different countries of the "developing" world. 21/ Given that most industrial technology has its origin outside them and that they must acquire it in relatively imperfect markets, the relatively less developed countries retain only a few prerogatives (which they frequently do not exercise, or only use them in a very imperfect fashion) such as that of a) choosing a more or less appropriate production technique within the spectrum of available ones, and b) negotiating the terms of transfer within the framework of a situation in which the differences in bargaining power of the parties to the contract play a predominant part.

For a number of years most of the Latin American literature on the subject of technology described the situation in the region as if "the" technological problem of the area was exclusively that of attaining a more or less successful acquisition of foreign technology.

We now know in fact that to take such a view is to oversimplify reality and that this is only the starting point of a large number of relevant problems in this field. Moreover, the most important differences to be found in the area of technology between "late industrializers" and the remaining nations in the underdeveloped world are to be found precisely in the post-sale period of the foreign technology, and have a more or less direct relationship with the presence or absence of domestic technological capacity. The latter is reflected in a certain flow of incremental locally generated technological knowledge, which acts as a complementary factor of production (via "adaptations", "improvements", etc.) to the originally imported technological design. 22/

21/ The empirical evidence reveals the existence of significant differences in the capacity of various developing countries to a)select technology and b) negotiate internationally to acquire it. Within Latin America, Brazil and Argentina frequently obtain better bargaining conditions than Mexico and the Andean Pact countries. See: J. Katz: Op.cit., Fondo de Cultura, 1976. Also: M.S. Wionczek, G. Bueno and J.E. Navarrete. La transferencia internacional de tecnología. El caso de México. Fondo de Cultura, Mexico 1974.

22/ This statement does not mean to deny a) that there is locally generated technological knowledge with a high degree of novel-

We shall argue here that Argentina, Brazil and Mexico have over time acquired a sufficiently large skilled professional and technical community which now "produces" a steady flow of technological knowledge which is complementary to the flow of imported technology. We shall also argue that such engineering and technical personnel is less likely to be available in the remaining countries in the region, a situation which means that the degree of "adaptation" to the specific local environments eventually reached by the imported technological designs is significantly lower than in the three above-mentioned countries.

Given that this point is important for an understanding of the situation in the region as far as technology is concerned, we believe it is necessary to examine first of all the subject of the complementary relationship between importing technology and domestic technological efforts, and then go on to explore the phenomenon of the presence or absence of domestic technological capacity and its connection with the degree of industrial, educational and technical development of a particular society. Let us begin with the first of these subjects.

II.1 Imported Technology and Domestic R & D

For several years conventional wisdom in this field of research has been based on the assumption that there is a negative relationship between importing technology from abroad and generating it locally. We now know - and the Japanese experience is a clear demonstration 23/- that this assumption is a gross oversimplification of

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ty, or b) that in certain circumstances it may happen that the relationship between local technological knowledge and foreign technology is one of substitution rather than complementarity. Both are feasible in specific circumstances, although the most widespread example we have been able to observe in the course of our empirical research corresponds to the complementarity model referred to in the text.

23/ Various papers demonstrate the complementarity between imported technology and local generation of technological knowledge in the Japanese case. The success of different industries in the international market has been interpreted as the result of their proven capacity to import and improve technologies already available

reality. While for economists the design of a product, or the specification of a production process are given technical data, which are assumed to be fixed and only very occasionally modifiable by discontinuous jumps in the technological knowledge they involve, the industrial engineer is accustomed to the idea that every engineering "blue print" is upgraded and improved over time, in response to the circumstances of its use in a specific context. In other words, the industrial engineer knows that there are no two plants (or product designs) in the world which are exactly alike, even if one of them attempts to be a carbon copy of the other. Since this is the case from a static point of view, there is all the more reason for it to be so in a dynamic analysis in which improvement and adaptation of the technological designs over time is allowed 24/

It is even more impossible for actual replication to occur when we refer to technological designs which must operate in physical and geographical environments which are completely different from those taken into consideration during the original conception of the technology with regard to the level of sophistication of demand, plant scale, supply conditions and quality of basic inputs, level of skill of manufacturing labor, etc.

The facts or circumstances which lead to a certain technological design being "inadequate" in a particular environment and make "adjustments", "adaptations", etc. necessary, are varied. 25/ Some are strictly engineering in nature, and have to do with the presence of "bottlenecks"in the original engineering design,

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in the USA or Europe. See H. Kitamura: Foreign aid and investment. New challenges to Japan. In developing Economies, December 1972. See also in connection with this subject: K. Oshima: Research and development and economic growth in Japan. In (ed.) B.R. Williams, Science and Technology in Economic Growth, Wiley, New York, 1973.

24/ The engineering bibliography has abundant examples of technological designs conceived as carbon copies of already existing ones, which when put into operation required substantial engineering efforts before reaching the desired output standard. See M.E. Clark, E.M. Forest and L.R. Stockey, Aches and pains of plant start-up. In Chemical Engineering Progress, Vol. 67 Nº 12.

25/ S. Teitel has set out in a recent paper a long list of possible "inadequacies" in the technology from developed countries when it is transferred to other relatively less developed ones. This list goes beyond the often mentioned subject of the inadequate capi-

26/ in a relatively similar sense to that which N. Rosenberg gives to his concept of "compulsory sequences" which are physical signals of "inadequacy" given out by a particular technological design demanding its "adjustment" or "adaptation" to the specific framework of a given situation. 27/

Other grounds for lack of adjustment or "inadequacies" are more strictly associated with economic variables (and not of an engineering nature) and may have to do both with microeconomic phenomena strictly related to an individual plant and/or with macroeconomic factors which affect complete branches of industry, or the overall manufacturing sector. Now, regardless of the reason for the "lack of adjustment" of the imported technology, what is certain is that it generates a certain demand for new "adaptive" technological knowledge which may allow a relatively more efficient use of the imported technological "blue print".

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tal/labor ratio which most frequently appears in the literature on "appropriate technologies". See, by the above-mentioned author: Acerca del concepto de tecnología apropiada. Trimestre Económico, July-September, 1976.

26/ In the case of the iron and steel industry it is common to observe the existence of "imbalances" and bottlenecks between different sections of the plant - for example, between the furnace's smelting capacity and that of finished product processing in the rolling mill - this being a constant source of demand for technological services aimed at eliminating the various "bottlenecks" which prevent increases in the physical volume of production. The elimination of these "bottlenecks" demands, of course, a constant technological effort on the part of the plant engineering team. An analysis of a situation of this kind can be seen in P. Maxwell's recent study of Acindar (Argentina): Learning and technical change in the steel plant of Acindar S.A. Monografía Nº 4 of the IDB/ECLA Science and Technology Research Program, Bs.As. December 1976. By the same author: First best technological strategy in an nth. best economic context. Ibidem, Monografía Nº 16, IDB/ECLA Program, Buenos Aires, April 1978.

27/ N. Rosenberg develops this concept in his book Perspectives on Technology. Cambridge University Press, 1976.

II.2 Domestic R & D and Skilled Human Resources

However, the fact that every "inadequacy" potentially generates an internal demand for technological knowledge complementary to the imported technology, is not sufficient reason to assume that these demands: a) will be satisfied or, b) should they be so satisfied, that it will be done by internal technological efforts within the plant or the country.

The available empirical evidence suggests that even when the domestic technological effort is significant in broad areas of the Argentine, Brazilian or Mexican manufacturing spectrum (probably in the last instance to a less widespread extent) in the remaining countries of the region the existence of an internal supply of professional and technical services able to take over the "production" of adaptive technology cannot be assumed to be obvious or automatic. There are undoubtedly specific areas of the Colombian (the textile branch, for example) or Venezuelan (the iron and steel industry or the petrol industry, etc.) manufacturing sectors where for historical reasons a professional and technical community of some significance has emerged and developed. Such, however, is the exception rather than the rule in most of the Latin American nations.

Broadly speaking, there are two kinds of "educational and labor training models, which we could call "supply-push" and "demand pull" respectively. While Argentina is a typical example of the first group, Brazil and Mexico must be visualized as representative of the second of the typologies we refer to.

In the case of "supply-push", as its name indicate, the development of the educational sector occurred very early this century and as the result of an autonomous political and institutional process which involved - in Argentina - the establishment of compulsory primary education in the twenties and a marked development of technical and professional schools in the forties and immediately after the War. This process was not the result of import substitution and industrial growth but reflected an autonomous proposal from the political system.

The almost complete eradication of illiteracy and the establishment of a tertiary and technical education sector of considerable size undoubtedly are two of the main factors which explain the relatively abundant supply of skilled labor which it is possible to find underlying post-war Argentine industrialization.

The educational sector's development as a function of the demands from the productive sector - "demand pull" situation-constitutes a completely different model from the previous one.

Experiences like those of Brazil or Mexico show that the educational "boom" has been a fairly recent phenomenon - occurring after the Second World war - basically involving the tertiary level while at the same time primary education has been quite neglected. 28/ The expansion of the educational sector was, in these cases, a response to industrialization rather than an autonomous development as in the model we mentioned previously.

Although this situation means that on average the industrial labor force is less skilled in these cases than in the Argentine context, the available evidence indicates that the "demand pull" model has had considerable success in generating the technical and

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28/ The following data are illustrative

Countries	Population over 5 years of age, in 1970				
	No education	Primary education	Secondary	University	Total
Argentina	1.715.800	14.729.050	3.338.650	720.350	21.034.750
Brazil	34.478.882	36.606.827	4.245.720	3.806.426	79.218.612
Mexico	13.364.134	21.393.508	2.933.842	567.695	38.370.438

Source: América en cifra 1974. Situación Cultural. OEA. Instituto Interamericano de Estadística

professional community demanded by industrial expansion 29/ 30/

In short: even if potentially all kinds of inadequacies in imported technology generate an internal demand for technological knowledge aimed at "adaptation" and "improvement", this demand may or may not be satisfied, depending on the extent to which skilled local labor is available which can undertake the task of "producing" the incremental technological knowledge required by all "adaptations" or "improvements". 31/

The lack of skilled labor is a structural feature which can

29/ The rate of expansion of tertiary enrolments in, for example, Brazil or Mexico, in fields such as engineering or the natural sciences, has been quite phenomenal, even though these societies as a whole still have an average illiteracy rate of the order of 30%. The following figures give an account of the educational "boom" referred to at tertiary level:

	1960	1965	1970	1975
Brazil -Engineers	11,106	22,121	48,118	75,515
-N. Sciences	3,447	6,915	41,124	75,120
Mexico -Engineers	15,327	26,007	62,501	n.a.
-N. Sciences	7,483	12,701	13,224	

Source: UNESCO. "Statistical Yearbook", several numbers.

30/ It is important to note that the "supply push" model has historically generated an excess supply of technicians and professionals who, when not absorbed into the productive sector, have given rise to a significant intra- Latin American flow of migration, from which countries like Brazil, Mexico, Venezuela, etc. have benefited by acquiring skilled human resources mainly from Argentina, Uruguay and Chile.

31/ The argument implies, of course, that incremental technological knowledge must be "produced" a novo, that is, that it constitutes an addition to the existing "state of the art" and not routine handling of available know-how.

only be modified over the long term since the creation and maintenance of professional and technical schools assumes an investment program which comes to fruition only over decades.

Hence it is reasonable to assume that the technological gap observable today between Argentina, Brazil and Mexico on the one hand, and the rest of the region, on the other, is unlikely to be reduced in the immediate future. It seems rather more logical to assume that this technological gap will bring about the growing "internationalization" of the economies of the more mature countries in Latin America, which are rapidly gaining ground in the region as: a) suppliers of sophisticated manufactures, b) suppliers of organizational and production technology in a large number of branches producing goods and/or services and, c) direct investors in third markets, by means of completely owned subsidiaries or "joint ventures" developed in conjunction with local firms in the recipient country.

Each of these developments involves a certain shift away from the traditional patterns associated with the import substitution process, and suggest that it will be advisable to examine them in greater detail if we are to achieve a correct diagnosis of the present state of affairsin the Latin American region. We shall now deal with the extent and economic repercussions of the domestic technological efforts detected in various Latin American countries.

III. EXTENT AND NATURE OF DOMESTIC TECHNOLOGICAL EFFORTS

In the previous section we argued that one of the main structural features which seems to distinguish Brazil, Mexico and Argentina from the rest of the countries in the region as far as technology is concerned, is the recent appearance - and gradual strengthening - of a domestic sector which creates technological knowledge and which complements the flow of technology imported from abroad with its own output of "adaptive" technology.

This sector can be located in Engineering Departments, in Technical Assistance to Production groups or in "trouble-shooting" teams of both large and medium-sized domestic firms and local subsidiaries of multinational groups or of public enterprises. 32/

This structural feature of the late industrialization model has so far received little attention, either at the empirical or theoretical level, there being obvious lack of concrete evidence as well as of a microeconomic theory of domestic innovative activity in countries at an intermediate stage of development, which would allow us, on the one hand, to throw some light on the main factors which determine business behavior regarding innovation, and on the other, to incorporate such an explanation into a broader analytical framework which would describe the growth path, the pattern of foreign trade, etc. of the kind of societies which concern us here.

In this section we shall briefly examine the magnitude, determining factors, nature, etc., of domestic R & D, leaving for the following section the study of the relationship between the domestic innovative phenomenon and the pattern of foreign trade and comparative advantages.

Let us first look at some of the available empirical evidence. This is still relatively sparse. Two studies related to the Argentine manufacturing sector reveal research and development expenditure which, towards the end of the last decade, were in the region of

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32/ As we shall see later, it is not easy to use a rigid criterion of nationality, size, membership of public or private sector, etc. to classify manufacturing firms into those that carry out domestic technological efforts and those who do not. A priori concepts and conventional wisdom are extremely dangerous in this field of research.

US$ 30 million annually. 33/ This represents, as an approximate average, between 0.3 and 0.4% of the annual sales of the industrial establishments surveyed in the papers quoted. 34/

Other recent studies show very similar figures, 35/ perhaps marginally higher in the pharmaceutical sector or in the electronics area. 36/ A recent report on the Mexican case, even though admitting that it covered only public sector research expenditure, while the ... " innovative efforts carried out by the production and maintenance staff, although certainly important to the country's industry were not covered", estimates expenditure on research and development in the Mexican manufacturing sector as in the region of US$ 12 million, which is approximately equivalent to 0.1% of the value of production of the establishments involved. 37/

The Brazilian picture confirms this, at the same time as it reveals a spectacular growth in research and development expendi-

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33/ These studies are: J. Katz: Importación de tecnología... Op. cit., Mexico 1976. Also by the same author: Creación de tecnología en el sector manufacturero argentino. Monografía Nº 2, IBD/ECLA, Bs. As. 1976. b. INTI (Instituto Nacional de Tecnología Industrial): Aspectos económicos de la importación de tecnología en la Argentina, Bs. As., November 1974.

34/ In both studies the unit of analysis was the 200 largest industrial establishments in the country, which as a group at that time accounted for nearly 40% of manufacturing product.

35/ P. Maxwell, in his recent study of the iron and steel firm, Acindar, and this author in an analysis of the technological history of the Ducilo Argentina rayon plant - subsidiary of Du Pont- find expenditure in the region of 0.3% of sales allocated to research and development activities. See P. Maxwell: Estrategia tecnológica óptima en un contexto económico difícil. Monografía Nº 16, IBD/ECLA Program, Buenos Aires, March 1978. Also J. Katz et. al. Productividad, tecnología y esfuerzos locales de investigación y desarrollo. Monografía Nº 13, IDB/ECLA Program, Buenos Aires, March 1978.

36/ The information can be found in J. Katz, op. cit., Fondo de cultura, Mexico, 1976. Various Argentine pharmaceutical firms show technological expenditure ranging from 1 to 2% of their annual sales.

37/ The analysis of the Mexican case can be seen in CONACYT: Política nacional de Ciencia y Tecnología, Mexico, 1976.

ture undertaken by the country's Public Sector. 38/

These are certainly not huge figures, but they cast some doubt on the a priori idea that domestic technological activity is practically non-existent. In the three countries mentioned it is possible to imagine the 100-200 largest industrial enterprises incurring research and development expenditure which, on average, we could place in the region of US$ 150 thousand annually per firm, a budget which certainly enables them to employ an experimental research and technological development team of, again on average, as many as 8-10 people.

The existence of this flow of domestic technological expenditure of course opens up a number of questions. It seems important to ask ourselves, first; What kind of technological activities are carried out locally?, or, in other words: What are the objectives of local R & D expenditure?; second: What micro and macroeconomic factors or circumstances encourage or discourage the undertaking of domestic research and development activities?; third: What direct effects do these local technological efforts have on the productive units which carry them out, and what are the various externalities which they generate?; fourth: What can we say concerning the advisability of this kind of domestic technological effort when we look at them from a macroeconomic point of view? Let us now look at some of these topics.

III.1. Type of Domestic Technological Efforts Carried Out

The first of the above-mentioned topics has to do with the definition of technological change itself. In one of the most detailed studies so far available on technology creation at plant level, S. Hollander writes: ... "We shall call technological change any modification in the production technique of a given product, put into practice by a specific plant, with the aim of reducing its unit pro-

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38/ Brazil's current Science and Technology program assumes a spectacular rate of expansion in research activities. In 1968 expenditure on S and T in this country amounted to only 200-300 million cruzeiros annually (at 1975 prices) while in the current S and T plan annual expenditure of the order of 6 billion cruzeiros annually is being programmed. See II Plan Básico de Desenvolvimiento Científico e Tecnológico, Presidencia de la República, Brasilia, 1976.

duction cost". 39/

In his well known 1960 study Salter defines the rate of technological progress in the same conceptual framework as Hollander, when he writes: "... the degree of technological progress from one period to another is defined and measured as the relative change in total unit costs, assuming that the technique used in each period is that which minimizes these unit costs". 40/

The two sentences reveal simultaneously the richness and limitations of the received body of theory. 41/

The richness lies - see Hollander's sentences - in that fact that all modifications to a plant's operating routine are considered to be "technological changes" independently of whether the modification is "major" or "minor", or of whether (or not) it is novel at the level of the industry or society. The limitation appears, of course, when, in an attempt to define the concept of technological change we only take into account those modifications to routine technical functioning associated with the reduction of unitary production costs, and ignore other possible effects of technological activity, such as quality improvement, diversification of the output-mix, increase of the physical output of a particular piece of equipment, 42/ replacement of imported raw materials and

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39/ S. Hollander: The sources of increased efficiency. A Study of Dupont rayon plants. MIT University Press, Cambridge, 1965. p.23.

40/ W.E.G. Salter: Productivity and Technical Change. Cambridge University Press, 1960, p.23.

41/ Recalling our statement on previous pages, we can note here that in the case of Hollander we are speaking of "endogenous" and "localized" technological change and not of the overall shift of a "meta production function".

42/ Obviously an increase in the physical volume of production must lead to a reduction in unit cost, since a given fixed cost will be divided among a larger number of units. This implies that any technological effort which enables the scale of production to be increased must necessarily have an effect on unit costs. However, we cannot ignore the fact that in that case ("output-stretching" technical change) the fall in costs is only an indirect or incidental result of a technological modification which was originally introduced with the aim of increasing the physical output of a given piece of equipment.

spare parts by local substitutes, 43/ etc.

Several of the studies carried out within the framework of the IDB/ECLA Science and Technology Research Program reveal that cost reduction has not necessarily been a priority of the technological activity undertaken by the firms studied. The launching of new products 44/ and the more effective use of installed capacity 45/ seem to have as or more important objectives than that of cost reduction. This seems to have been so particularly in those situations in which we have been able to detect at the same time either low market competition or, alternatively, competition not based

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43/ Even though substituting one imported raw material for a domestically produced one (not always the exact equivalent) may well not have a direct effect on costs - or may even exercise a negative effect- this does not prevent such a substitution from demanding a significant technological effort for it to be put into operation. Looking exclusively at cost data can lead us to lose sight of this.

44/ Both the paper by Lucángeli, Fidel and Shepherd relating to the cigarette industry, and Vitelli's research on the construction sector show how the launching of new products is the main objective of the technological activity of firms in these sectors. In both cases this is hardly connected with the aim of reducing production costs. See a) J. Lucángeli, J. Fidel y P. Shepherd: Perfil y comportamiento de la industria del cigarrillo en la Argentina, Monografía Nº 7, IDB/ECLA Program , Bs.As. December , 1976; b) G. Vitelli: Competencia, oligopolio y cambio tecnológico en la industria de la construcción. El caso argentino, Monografía Nº3, IDB/ECLA Program , Bs.As. December 1976.

45/ The previously cited study on the Argentine rayon industry clearly shows that during the period 1937-1950 when Ducilo Rayon held the monopoly in the domestic rayon market, its technological strategy consisted of searching for a higher spinning speed in order to produce more kilos of rayon with the available equipment. During this stage there was little "technological search" aimed at reducing costs. However, the latter became the nub of technological strategy during the sixties and seventies when the market became much more competitive with the entry of Sniafa and Reysol. See: J. Katz et al., op.cit., Monografía Nº 13, IDB/ECLA Program, Buenos Aires, March 1978.

specifically on prices, but on quality, product differentiation, etc.

If we look at these results from the point of view of received theory - which, according to what we have seen, is based on the asumption that the main aim of technological activity is cost reduction - it is difficult to avoid feeling that that theory still lacks the necessary flexibility to capture and describe the technological phenomenon of many industrial markets in Latin America, which for historical reasons have so far been more protected and concentrated than those of the USA or Europe and therefore have provided less incentive for search for lower production costs and, on the other hand, have encouraged technological strategies of product differentiation, or similar ones, associated with oligopolic competition.

In short: with regard to the type of technological efforts discovered in the various studies on technology creation on the Latin American scene, the available evidence suggests that they respond to a variety of objectives, among which cost reduction is only one, and not necessarily the most important one. In a less competitive world than the developed one the search for operating efficiency may well be less important than other alternative strategies. This situation gives rise to somewhat different "technological behaviors" from those which have mainly been studied in received literature.

III.2. Micro and Macroeconomic Variables which Encourage or Discourage Domestic Technological Efforts

Let us now move on to the second of the above-mentioned topics, that is, the micro and macroeconomic variables which affect (positively or negatively) the propensity of the economic agents to undertake local technological efforts. Among the microeconomic factors which influence the extent and nature (bias towards the relative saving of a particular factor) of domestic technological efforts, it seems advisable to mention: a) the initial design conditions; 46/

46/ In a paper to be distributed shortly, F. Sercovich studies the relationship between initial design conditions in an industrial plant - his examples are taken from the Argentine petrochemical sector - and the technological strategy followed by different firms in the sector after plant start-up. This author

b) the nature of the product 47/ and the market in ques-

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notes that ... "almost no industrial process is so completely known that a new plant can be designed simply from library programs representing a theoretical solution". This implies that there is generally a broad margin during the design stage for ad hoc solutions, based on experience with previous designs. Besides this technical uncertainty arising from the imperfect level of information about the productive technique finally chosen, it is also true that during the design stage the engineering team must necessarily opt for one of the possible solutions and reject others in order to evaluate the former in greater detail. It is then that there is a certain loss of technical information involved in the non-evaluated solutions, and also the inevitable interference of the design parameters inherent in the socio-economic environment of the country of origin of the technology. As a result of the first element - technical uncertainty - and the second - incomplete evaluation of alternatives or use of technical parameters belonging to a developed country - it is not uncommon to observe that the chosen solution later presents problems of over or under design which determine both the magnitude and nature of local innovative efforts. See: F. Sercovich: Ingeniería de diseño y cambio technológico endógeno. Monografía Nº19 (in print) IDB/ECLA Program, Bs. As. June 1978. On this point, Sercovich's analysis is closely related to N. Rosenberg's argument about the existence of "compulsory sequences" which direct the technological search activity of a particular firm. See: N.Rosemberg, Perspectives .... Op.Cit. Cambridge University Press, 1976.

47/ In his study of the construction sector, G. Vitelli shows how the individual nature of the "products" manufactured by this industry to a large extent determine the kind of technological efforts which the construction firms must undertake. There are marked differences in this respect between the construction of dwellings - a relatively standardized product - and large infrastructure works, such a large dams, roads, etc. In the latter kind of works there is practically no repetition and this means that new technical specifications must be drawn up for each particular case. Put another way: the "product" specification requires a substantial research and development effort before (by the institution ordering the work) and after (by the construction firm) the work is tendered. See G.Vitelli: Competencia, oligopolio y cambio tecnológico en la industria de la construcción. Monografía nº3, IDB/ECLA Program, Bs.As., December 1976.

tion 48/; c) the relationship with the foreign suppliers of the technology involved (whether this is the parent company, a licensing firm or an equipment supplier); d) the quality of the engineering team employed, 49/, etc.

Another study in which it can be seen how the nature of a product or, in this case, of substitutes - influences the "technological search" path followed by a particular engineering team, is that by this author related to the rayon manufacturing plant of Ducilo Argentina (subsidiary of the Du Pont group). The appearance of nylon in the Argentine market and the consequent contraction in demand for rayon it produced led Ducilo's department of Mechanical and Chemical Experimentation to study in greater depth two technological improvements to their production process, the spinning of High Solids and the spinning of Polynosic Yarn. Both technological changes substantially improve the quality of the manufactured product at the same time as facilitating savings in production costs. The increase in quality partly counteracted the negative impact of the appearance of nylon. See J. Katz et al. Productividad ... op.cit. Monografía Nº 13, IDB/ECLA Program.

48/ With regard to the relationship between local technological efforts and market structure (and the changes in the latter over time), two papers of the IDB/ECLA Program provide interesting information. During the first two-three decades of Acindar's (iron and steel) and Ducilo's (rayon) operation, the R and D "projects" undertaken locally by the two firms are basically aimed at eliminating "bottlenecks" which prevent the increase in the physical volume of production attainable with the available equipment. This coincides with a stage in which the two firms are operating in buyers markets, in which excess demand can be observed. The second half of the fifties and the sixties show a substantially different picture. The level of competition prevailing in the market has grown considerably. Both firms now operate in sellers' markets in which costs and quality (above all the latter) are two priority areas for local innovative activities. For the two papers see P.Maxwell, Learning and Technical Change in the steelplant of Acindar S.A Monografía nº 4. IDB/ECLA Program, Bs.As. December 1976 and J.Katz, et.al. Productividad ... Op.Cit. Monografía nº13, IDB/ECLA Program.

49/ We have noticed marked differences in the quality and technical training of the R and D teams of firms competing in the same

These microeconomic factors affect a) the original choice of technology, b) its adjustment to local circumstances and the extent to which the chosen technological design approaches optimum conditions, c) the direction and productivity of the different innovative programs to be undertaken by a specific firm after plant start-up.

In addition, several of the studies carried out show how microeconomic variables affect the amount and nature of locally generated technological knowledge. Among these are: the exchange rate, the interest rate, the cost of skilled labor, 50/ the rate of growth and fluctuations in the economy, the degree of uncertainty with which the latter operates, etc. Together with the above-mentioned microeconomic variables, the latter determine both the rate of investment and the opportunity cost of the decision to continue operating with equipment of an older "technological vintage" reconditioned and "improved" by local innovative efforts. 51/ Taken together, our re-

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market. Thus, while Ford Argentina for example, employed more than 200 people in its Product Engineering Department, other firms in the same automotive sector had made only marginal incursions into local innovative activity. Identical examples can be located in practically all and every one of the branches of industry.

50/ J. Lucángeli and J. Fidel have recently completed an interesting exercise relating to the Argentina tobacco sector in which they compare: a) the internal rate of return of a program of equipment replacement in a cigarette manufacturing plant, with b) the alternative level of profit attainable by means of the modification and improvement of the available equipment, which is representative, on average, of the technological vintage of the fifties. These authors conclude by saying that three variables - the exchange rate, the cost of the raw material and the wages of skilled labor - affect the choice between modernizing and replacing the machinery employed. See J. Lucángeli and J. Fidel: Costos y beneficios de distintas opciones tecnológicas en el marco de un oligopolio diferenciado - La industria del cigarrillo. Monografía Nº 18, IDB/ECLA Program, July 1978.

51/ The theoretical model used by J. Lucángeli and J. Fidel in the study quoted above has been developed by A. Canitrot in a IDB/ECLA Program paper in which he examines the role of macroeconomic variables as determining factors in different kinds of investment and innovation behavior. See: Un esquema para evaluar el

sults relating to the micro and macroeconomic variables which affect local innovative activity seem to suggest that the firms do in fact generate a technological response when faced with the restrictions and "bottlenecks" imposed by the technology originally selected, and also when confronted with changes in the contextual variables with which these firms operate over time (for example: degree of competion prevailing in the market, cost and availability of raw materials, relative cost of labor and capital - exchange rate, labor legislation, etc.). As C. Freeman says: "this response by the firms is most likely (and effective) when the change is more drastic and, therefore, more clearly perceived". 52/

We here close our brief summary relating to the second of the questions we raised previously. Our next section examines the relation between these local technological efforts and the operating performance - both at home and abroad - of the firms which undertake them.

III.3. Domestic Technological Efforts and Economic Performance

Of the several consequences which arise from the existence of a flow of R & D activity produced independently at plant level, two are particularly important from the point of view of their effect on long term growth.

The first has to do with the aggregate impact of these technological efforts on overall productivity of the factors employed by the firm which undertakes them. The second consequence partially arises from the foregoing, and relates to the effect of the increase in productivity on the relative gap which separates a particular industrial plant from the "average standard" prevailing internationally in a specific field of manufacturing production. We shall argue here that the increase in productivity and the existence of adaptive technological efforts are necessary (although certainly not sufficient) conditions for a firm to approach international competitive standards, making feasible its eventual participation in regional or extra-regional third markets.

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significado de las variables macroeconómicas en el análisis de incorporación de tecnologías, Monografía Nº12, IDB/ECLA Program, September, 1977.

52/ C. Freeman: "Technical Change and Unemployment". Paper given at the conference on "Science, Technology and Public Policy", University of New South Wales, December 1977, Mimeo, p.8.

Let us look at the two topics separately, beginning with that referring to the impact of domestic technological activity on factor productivity.

a. Domestic R & D and Productivity Growth.

Various studies carried out in recent years confirm the great importance of "minor" technological change as a source of substantial increases in manufacturing productivity. Perhaps the most detailed of these papers is that by S. Hollander, who, after studying several rayon producing plants belonging to the firm of Du Pont in the United States, concludes by saying that: "... The contribution of "minor" technological change to increased efficiency over time has been of great importance in the cases we have analyzed. The relative effect of minor technological changeas a proportion of overall technological change is 100% in Spruance II, 83% in Spruance II-A, 80% in Spruance I, 79% in Old Hickory and 46% in Spruance III". 53/

Other authors, using less detailed methodologies than Hollander's, basically confirm the same view. The most important among them are the studies by N. Terleckij, 54/ J. Enos, 55/ J. Minasian, 56/ Z. Griliches 57/ and others.

53/ S. Hollander, The Sources of Efficiency Growth, MIT, University Press, 1966, Chapter IV, p. 120.

54/ N. Terleckij, The sources of Productivity Advance. A Pilot Study of Manufacturing Industries, unpublished doctoral thesis, Columbia University, 1960. (Microfilm version, Ann Arbor, Mich., 1970).

55/ J. Enos, "Invention and Innovation in the Petroleum Refining Industry", in: (Ed. R. Nelson), The Rate and Direction of Inventive Activity, NBER, p.93, Princeton, 1962.

56/ J. Minasian, "The Economics of Research and Development", in: (Ed. R. Nelson), The Rate and Direction of Inventive Activity, NBER, p. 93, Princeton.

57/ Z. Griliches, comment on W.F. Moeller's article "The Origins of the Basic Inventions Underlying Du Pont's Major Product and Process Innovations, 1920-50", in (Ed. R. Nelson) op. cit., p.323. Also, by the same author, Research expenditure and growth Accounting in: Science and Technology in Economic Growth, Mac Millan, London, 1973.

Various pieces of research carried out during the last few years in the Latin American area describe a relatively similar scenario with regard to the explanation of productivity increases; A. Petrecolla et al 58/ with reference to the Argentine electronic industry, M. Ramírez Gómez on electrical power generation in Colombia, 59/ the present author both within the framework of inter-industry research which includes the 200 largest manufacturing firms in Argentina, 60/ and in the much more detailed context of a microeconomic study similar to that undertaken by Hollander in a rayon producing plant, 61/ etc., all show that in the context of "late industrializers" the flow of domestic technological efforts, the great majority of which are "minor" in nature, also has a very significant effect on the growth-path of manufacturing productivity.

Several of these studies also show that in countries of "late industrialization" locally generated technological change tends to be: a) relatively less labor-saving and b) more frequently of a "disembodied" nature - adjustments and improvements to products and/or processes - than that obtained through the purchase of technology and foreign technical assistance. 62/

In short: the statistical relationship between technological

58/ A. Petrecolla, R. Zubieta, H. Abrales y J. Nogués, Industria electrónica y progreso técnico en un contexto de industrialización, Editorial del Instituto, Instituto Di Tella, Buenos Aires, 1974.

59/ M. Ramírez Gómez: Cambio tecnológico en la industria de generación de energía eléctrica de Colombia. Monografía de Trabajo Nº 8, IDB/ECLA Program, Buenos Aires, December 1976.

60/ J. Katz, Importación de Tecnología, Aprendizaje e Industrialización Dependiente. Fondo de Cultura Económica, México 1976.

61/ J. Katz, M. Gutkowski, M. Rodrígues y G. Goity. Productividad, Tecnología y Esfuerzos Locales de Investigación y Desarrollo. (Estudio de una planta productora de rayon). Monografía de Trabajo Nº13, IDB/ECLA Program, Buenos Aires, 1978.

62/ See, for example: 1)J.Katz et.al. Productividad,...Op.cit. Monografía de Trabajo Nº13, IDB/ECLA Program, Bs.As., 1978; 2) M. Ramírez Gómez: Cambio Tecnológico... Op.Cit. Monografía de Trabajo Nº 8, Bs.As., 1976.

expenditure and overall increases in productivity which the literature on "sources of economic growth" has examined in relation to developed countries during the sixties, does not seem to apply exclusively to mature industrial societies. 63/ Where the presence of skilled human resources at the plant level makes feasible the domestic production of new technological knowledge, it can be expected that after a certain number of productive periods, and by means of a process of accumulation, the flow of domestic technological efforts will become the main "explanation" of the growth observed in manufacturing productivity.

There is no obvious reason to assume that the relative productivity of these technological efforts - and their immediate counterpart, which is the rate of increase in overall factor productivity - must necessarily be any greater or any less in industrial plants which operate in the same sectors of activity in relatively more advanced countries. In principle there is nothing to prevent a particular firm established in Brazil, Mexico, Argentina, etc., from improving its relative position in the international scene by means of "adaptive" technological activity and gradually closing the relative productivity gap which separates it from the world "average standard", eventually reaching a position of potential competitiveness in third markets. In our opinion a situation of this type seems to underlie the growing international competitiveness of several of the "late industrializers' which in the last few years have been very successful both as exporters of technologically sophisticated manufactures and of technology as such. The following section of this paper examines briefly developments in this area, which still requires a considerable amount of research.

b. Domestic Technological Efforts and Export Capacity

We have already seen that domestic technological efforts are often carried out by firms which operate on the basis of an imported technological design as the result of a need to adapt this design to local market and environmental conditions. This need for adaptation may have to do with: a) the type, cost, etc. of the raw

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63/ Of course, the specification problems which underlie this statistical relationship, which have already been discussed with reference to studies carried out in developed countries, are also present when the same statistical relationship is estimated for the Latin American nations.

materials locally available; 64/ b) the relative factor price in the local market; c) the scale of the plant; d) the climatic, geographical, etc. conditions in which the product and/or process are used locally; 65/ e) specific characteristics and requirements of the local consumer with regard to quality, maintenance, servicing, etc. 66/ f) the nature of the by-products arising from the product manufactured or the process employed; g) differences in the legal and institutional framework, in the labor field or in the local market structure, 67/ etc.

Once the various inadequacies of the imported technological design have been overcome - by means of "minor" local innovations-

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64/ It is common to find, for example in the petrochemical area, firms which at the beginning of their local operation used imported raw materials which were subsequently replaced by local substitutes. This replacement usually required applied research efforts, experimental work in pilot plants, etc.

65/ The automotive industry, tractor production, etc. are typical examples of industries in which the country's physical infrastructure has forced most of the industrial establishments which operate in the domestic market to introduce significant modifications and adaptations into technological designs originating in the United States or in Europe. See in this connection the cases of Ford and Fiat referred to in a previous monograph, J. Katz and E.Ablin, op.cit., Desarrollo Económico, Nº 65, Vol.17, 1977.

66/ The electronics consumer industry or the automotive sector are often quoted as examples of branches of industry in which the domestic consumer does not make demands of a level of sophistication comparable to those made in mature industrial countries. In these cases domestic technological efforts may well be aimed at reducing the level of sophistication of the foreign technological designs.

67/ The recently concluded study on the rate of technological change in the Ducilo Argentina rayon plant reveals that Argentine labor legislation is in several respects (e.g. air conditions, in various sections of the plant, evironmental conditions, etc.) more rigorous than that of, for example, the United States. This obliged the firm's engineering team to carry out technological work in order to comply with legal and institutional requirements which the original technology never contemplated.

it seems intuitively clear that the available technological "package" ("blue-prints", engineering rules, etc.) must necessarily be different from the one originally obtained from abroad. Whether in "embodied" form (in the end product, in the equipment used in its production, etc.) or in "disembodied" form (in terms of engineering procedures, management rules, etc.) the "new" technological package must have a higher degree of adjustment to local conditions than did the original technological design. 68/

In these circumstances it is not surprising that the "new technological package" should be well received in third markets characterised by features of geography, climate, institutions, size, type and price of available factors and raw materials, etc., to some extent similar to the local characteristics which produced the need for adaptive technological efforts.

In other words, in these circumstances it is hardly surprising that the adaptive technological activity should give rise to the eventual appearance of a "new" product or process capable of earning profits when sold in third markets. 69/

This may occur by means of various mechanisms, as for example: 1. direct exports of products containing "embodied" technology; 2.

68/ In other words, the "new" technological package is a more "appropriate" production function with respect to local conditions.

69/ Strictly speaking, this "new" product or process may also earn additional profits in its own market of origin, either by enabling its owner to expand the volume of production or through a license to third parties. There are, however, reasons to believe that this latter course of action will not normally be chosen by the owner of a technological package of the kind examined here. On the one hand, it is unlikely that the owner of a "new" technology will be interested in licensing it to another firm operating in the same market. On the other hand, and as a consequence of the very nature of the technological knowledge involved in the "new" technological package - which does not constitute a major shift away from the prevailing state of the art, but "sub-innovations" relatively accessible to firms already competing in the innovator's market - its resale value will presumably be less than it could eventually command in foreign markets.

direct investment programs; 3. granting the rights of utilization of a licenseto third firms; 4. the sale of a complete plant; etc.

During the last few years the following have been gaining in importance: a. the export of industrial manufactures - among which can be found items of relative technological complexity that have required domestic R & D efforts of some significance, such as cars, tractors, antibiotics, electromechanical equipment, agricultural machinery, etc.- b. the sale of complete plants through "turnkey" contracts and c. programs of direct investment by local manufacturers in third countries in the region.

Some of these topics have been studied in recent years but practically all of them still require a detailed research effort. We know, for example, that the local subsidiaries of multinational firms control a significant proportion of the intra-regional exports of sophisticated manufactures, 70/ but they do not weigh very heavily in relative terms in the increasing flow of exports of pure technology 71/, a flow which seems to be associated with medium-sized firms, domestic engineering firms and financial arrangements undertaken by local banks. We also know that the export of sophisticated manufactures and turnkey plants is not restricted to the Latin American examples we have mentioned - Argentina, Brazil and Mexico - but that it is also growing in importance in Korea, Singapore and Taiwan. 72/

70/ See in this connection, J. Katz and E. Ablin: Tecnología y exportaciones industriales: Un análisis macroeconómico de la experiencia argentina reciente. Desarrollo Económico, Nº 65, Vol. 17, pp. 89-132, Bs.As., April-June 1977.

71/ In a recent IDB/ECLA Program paper we have had the opportunity to study 35 cases of the export of "turnkey" plants undertaken by firms established in Argentina. Only 6 of these export agreements were accounted for by multinational firms and involved the participation of the respective Argentine subsidiary. See: J. Katz and E. Ablin: De la industria incipiente a la exportación de tecnología: la experiencia argentina en la venta internacional de plantas industriales y obras de ingeniería. Monografía de Trabajo Nº 14 of the IDB/ECLA Science and Technology Research Program, Bs.As., April 1978.

72/ See: J.Katz et.al. Op.Cit. Productividad, tecnología y esfuerzos locales de investigación y desarrollo. Monografía de trabajo Nº13, IDB/ECLA Program, Buenos Aires, March 1978.

By way of example, the following tables offer empirical evidence referring to the Argentine case; what we know about Brazil, 73/ Mexico, 74/

73/ In the hope that Brazilian exports of services will increase rapidly, the President of the Bank of Brazil revealed that bid bond transactions rose from US$ 2.2 millon in 1974 to US$ 38.3 million in the first nine months of 1976. Likewise, performance bond transactions, which did not exist in 1974, reached US$ 2.7 million between January and September 1976. On the other hand, the measures undertaken by CACEX to promote the sale of engineering studies and projects overseas include credits for US$ 75 million to finance the construction of airports in Bolivia, sanitation works and pipelines in Paraguay, a hotel in Peru, and communications between Brazil, Bolivia and Peru, as well as the exploitation of water resources in Senegal.

The foregoing is the translation of a statement made by Angelo Calmon de Sá, President of the Bank of Brazil, during a Services Export Seminar held in the auditorium of Itamaraty and published in the Jornal do Brasil on 22nd October, 1976.

74/ With reference to Mexico, between January 1973 and July 1975 exports of technology and special services reached a value of US$ 137 million, a figure which can be considered promising given the incipient nature of the process and the strong growth of this type of exports since the last date mentioned. In fact, if we bear in mind that the plant sold to Argentina in 1976 for the production of newsprint from sugar cane bagasse in the Province of Tucumán alone involves an investment program costing US$ 200 million, one can have some idea of the dimension of what is happening in this direction. Mexico has successfully approached the sale of plants through - among others - four basic technologies developed locally: i) H and L's (Hojalata y Lámina) technology for direct reduction in the iron and steel industry. The Venezuelan firm of SIDOR has set up its Orinoco steelworks using this system, which is also incorporated - or about to be incorporated - in the iron and steel industries of Brazil, Irak, Iran, Indonesia and Zambia. ii) DEMEX technology developed by Petróleos Mexicanos (PEMEX) for metal extraction from crude oil during refining (used in Colombia and Jamaica), and a refining system which will be marketed by UCP Inc., one of the largest consulting firms in the petrochemical area. iii) The Cortina method, conceived by I.C.A Construcciones for premoulding concrete structures, already used in Colombia and Venezuela. iv) The Cusi process - belonging to Bufete Industrial - for the manufacture of newsprint from sugar cane bagasse.

Table 1. Argentine Industrial Manufacturing Exports 1969-76

Year	Industrial Manufactures (1)	Total Exports (2)	(1)/(2)
	Argentine Exports 1969-1976 (in millions of US$)		
1969	166	1,611	10.30
1970	191	1,772	10.78
1971	211	1,740	12.13
1972	278	1,941	14.32
1973	596	3,265	18.25
1974	836	3,929	21.28
1975	628	2,961	21.21
1976	794	3,916	20.28

Source: Secretaría de Estado de Comercio Exterior

Table 2. Some Examples of Internationalization of Argentine Manufacturing Firms 75/

Firm	Activity	Country in Which Established
Siam di Tella	Electromechanical	Brazil
Roque Vassalli	Agricultural Machinery	Brazil
Industrias Siderúrgicas Grassi	Ferro-alloys	Brazil
Rosati y Cristofaro	Metal Structures	Venezuela
Bagó	Pharmaceutical Products	Peru
Aurora	Electronic Lighters	Brazil and Spain

Source: Drawn up by author.

Furthermore, 29 technology exporting firms have gathered to form a group called Tecniméxico, which has state support, in order to coordinate the supply of engineering services. For this information, see Business Week, 4th August, 1976, McGraw Hill Inc, and Tecniméxico's own list of activities, which shows it to be undertaking engineering works and installations of complete plants in more than 10 Latin American countries.

75/ This topic, closely connected in this country with techno-

Table 3 Complete or Turnkey Plants and Engineering Works Exported by Argentina during the Period 1973-1977

Firm		Destination	Year	Value in US$
1. De Smet Arg. S.A.	Vegetable oil factory	Bolivia	1973	5,524,873
2. Nisalco S.A.	Plant for production of cooked meat and meat extract	Brazil	1973	200,000
3. Standard Electric Arg.S.A.	Automatic Telephone exchange and external communications plant	Ecuador	1973	678,857
4. Sicom S.A.	Thorough communications system for public service	Chile	1973	2,829,398
5. SEI Ingeniería S.A.	Meat combine. Complete slaughterhouse and meat-packing plant for beef	Cuba	1974	12,500,000
6. Phoenicia S.A.	Complete bakery plant	Cuba	1974	2,900,000
7. Nisalco S.A.	Glycerine production plant	Mexico	1974	90,000
8. Emepa S.A.	15 storage sheds with metal structures and facings for port storage	Cuba	1974	6,775,007
9. Emepa S.A.	Sheds with metal structures and decks and silos for poultry farms	Cuba	1974	15,940,532
10. Talleres Adabor S.A.	Metal silos With integrated transporters	Cuba	1974	2,829,073
11. Lix Klett S.A.	Air conditioning, ventilation and heating installation for a bank building	Paraguay	1974	90,000
12. Meitar Aparatos S.A.	Citrus fruit processing	Cuba	1975	6,200,000
13. Dosicenter S.A.	Two plants for honey production	Cuba	1975	1,490,000
14. Eximparg S.A.	Plant for extraction of vegetable oil from cotton seed	Bolivia	1975	4,000,000
15. S.A. Lito Gonella e Hijo	Supply, distribution and pumping terminals for liquid gas	Ecuador	1975	1,998,300
16. Techint S.A.	Oil pipeline and pumping stations	Peru	1975	120,000,000
17. Laboratorios Bagó S.A.	Antibiotic production plant	Bolivia	1975	220,000
18. Benito Roggio e Hijos S.A.	Turnkey airport	Paraguay	1975	52,000,000
19. Nisalco S.A.	Water treatment plant for industrial use	Uruguay	1975	47,300
20. Meitar Aparatos S.A.	Processing of citrus fruits, pineapple and mandioca	Bolivia	1976	8,810,000
21. Establecimientos Gele Electromecánica S.R.L.	Plant for spice processing and packing	Cuba	1976	1,441,000
22. De Smet Arg. S.A.	Complete plant for oil extraction via solvents and pellet plant for the processing of sun-flower & soya cakes	Uruguay	1976	746,376
23. Harial S.A.	Plant for production of lead oxide	Venezuela	1976	146,800
24. Harial S.A.	Plant for lead smelting and recovering	Venezuela	1976	135,700
25. Cemati S.A.	Manufacture of forge spare-parts for electric plants	Bolivia	1976	146,466
26. Phoenicia S.A.	Complete bakery plant	Chile	1976	114.971
27. Industrias Metalúrgicas Caissutti S.A.	Poultry slaughtering and processing plant	Paraguay	1976	188,671
28. Giuliani Hnos. S.A.	Balanced powdered food factory	Bolivia	1976	239,173
29. Gases Industriales S.A.	Fats refining plant	Chile	1976	286,256
30. Secadoras Iradi S.A.	Grain processing and storage plant	Uruguay	1976	483,572
31. Laboratorios Bagó S.A.	Plant for extraction of active elements from vegetables	Honduras	1976	450,000
32. SEI Ingeniería S.A.	Plant for manufacture of sodium caseinato and/or calcium and powdered buttermilk	Uruguay	1977	269,854
33. Tecnimontsade (Consorcio Italo-Argentino)	Plant for pesticide manufacture	Bolivia	1977	45,000,000
34. Latinoconsult S.A.	Turnkey hospital	Ivory Coast	1977	46,000,000
	TOTAL			340,742,179

Source: Prepared by the authors with original information.

India, 76/ etc. is still very limited but nevertheless suggestive.

A reading of the foregoing tables, and the existence of parallel empirical evidence indicating that a similar phenomenon is in full process of development in Brazil and Mexico suggest the possibility that the three "late industrializers" within Latin America are today beginning to produce their own cycles - also belated - of direct foreign investment and exports of sophisticated manufactures and pure technology.

In other words, two or three decades after experiences like that of Japan or Italy, on a much reduced scale and within the context of a greater structural weakness, these three countries would appear to be showing various features of "capitalist maturity" usually attributed to more developed countries.

In the same way as with other structural features of late industrialization, examined briefly in earlier pages, this apparent novelty calls for both a theoretical interpretative framework and for economic policy instruments which, at both the domestic and inter-regional level, will cooperate to give a legal and institutional organization to the phenomena uncovered by socio-economic research.

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logy exports, should be the subject of a wider debate, which is already taking place in Argentina. An example of the awareness of this phenomenon is the creation of an Office for Overseas Investment (Dirección de Inversiones en el Exterior) by the Economy Ministry (see La Nación, 1/11/77). At the academic level there are a few introductory monographs which should be followed up. See Louis Wells, The Internationalization of Firms from the Developing Countries, Graduate School of Business Administration, Harvard University, January 1976. See also the article by Carlos Díaz Alejandro, Direct Foreign Investment by Latin Americans, Mimeo, Nuffield College, Oxford, 1976. Dr. E. White, of the Instituto Latinoamericano para la Integración (INTAL) is at present carrying out a study on this subject, and has found some 50 cases of interest in the region as a whole.

76/ See, in connection with the Indian case: S. Hall: Developing countries as exporters of technology. A preliminary analysis. Op.Cit., Mimeo, June 1978.

III.4 Domestic Technological Efforts and Resource Allocation

Previous sections of this report have enabled us to establish on the basis of material gathered in various studies in the IDB/ECLA Program:

a. That there exists a significant flow of domestic technological efforts carried out at manufacturing plant level - especially in Argentina, Brazil and Mexico and to a lesser extent in Colombia, etc.- aimed at "adapting" and/ or "improving" technological designs imported from abroad.

b. That these technological efforts have various aims, among which can be mentioned the expansion and improved exploitation of installed capacity, the launching of new products, the improvement of the quality of existing products, the use of domestic raw materials to replace imported ones, cost reduction, etc.

c. Contrary to what is assumed in most of the literature, only a small fraction of the technological efforts observed is aimed at reducing unit production costs, a fact which is probably associated with the higher level of protection and oligopolic concentration enjoyed by the different industries examined in Latin American countries.

d. That the accumulated flow of domestic technological efforts has a significant impact both upon overall factor productivity at plant level, and upon the export capacity of the firms which undertake them.

e. That the latter is reflected both in the growing export capacity of technologically complex manufactures and in an incipient but clear trend towards the export of technology in the form of "turnkey" plants, technical assistance contracts, provision of basic and detail engineering for infrastructure works, units for the provision of services (such as hospitals, airports, etc.)

Now despite the intrinsic interest of the foregoing results, they do not enable us to finally establish whether or not we are in the presence of a flow of domestic technological efforts which, evaluated from a social (and not private) angle, can be considered to be an efficient allocation of resources. In other words, we have not thus far been able to establish whether such domestic technological efforts lead in the long run to society's maximizing the rate of growth of its per capita income.

In fact, from a social point of view, the latter is a crucial question for an evaluation of the cost/benefit ratio of the resour-

ces allocated to research and development tasks of the kind examined in this paper, since it may well be true that by means of domestic technological activities and "minor" innovations, a particular country is artificially maintaining in operation industrial plants, or even branches of industry, which are relatively far from the country's dynamic comparative advantages.

This subject has scarcely been studied during the first phase of the IDB/ECLA Program. To do so it would be necessary to make a detailed study of matters inherent in the pattern of dynamic comparative advantages, in the structure of industrial markets, etc., topics which have only marginally been studied in some of the Program's papers.

In order to approach this analysis, it would be necessary to distinguish between different situations. On the one hand, we find examples of manufacturing activities which clearly form part of the comparative advantages of a society and which from the outset can operate without any kind of subsidy or protection. The allocation of resources for the creation of technology in these activities, will by definition be profitable from a social point of view.

A second example is that the "infant industry", which needs a certain degree of protection to survive and expand. The allocation of resources for the creation of technological knowledge is justified here when productivity growth eventually allows protection to be withdrawn and the industry in question to be included among those which correspond to the subset where the country attains comparative advantages of the traditional sort. The time factor becomes an important element in the analysis of the cost which society must pay by subsidizing learning.

These two situations do not exhaust all the possibilities. Given that there is not just one single "technological path" but, as we have seen in previous sections, various possible alternative technological strategies, the analysis should also undertake a comparative study of these, in order to evaluate the results which could have been obtained with different strategies from the one adopted.

In order to complement the analyses previously suggested it also seems necessary to study the greater or lesser degree of transfer of the results of the technological progress to the final consumer, an evaluation which, depending on market structure, will enable us to judge the true impact of the technological activity on the society's development.

All these topics have been marginal to the studies so far

undertaken by the IDB/ECLA Program. There is no doubt that they constitute areas of research which will have to be given more attention in the near future.

IV. FINAL COMMENTS

Previous sections of this paper present a brief synthesis of some of the most interesting results arising from the research undertaken by the IDB/ECLA Science and Technology Program. At the same time, we make a number of comments on the role of domestic technology creation in countries of "late industrialization", and the increasing importance of technological factors in the formation of a new Latin American and international scenario.

It is obvious, however, that the studies carried out within the framework of the IDB/ECLA Program do not go beyond the analysis of a very specific area, which is the topic of domestic technology creation in various branches of manufacturing in different Latin American countries. In doing so, it consciously ignores many other topics of importance from both the theoretical point of viw and that of the formulation of a technological policy. It is therefore worth while making clear here that the choice of this field of study does not mean to underestimate the importance of the various other topics which belong to the "technology field". On the contrary, our research strategy has opted to give priority to areas little analyzed so far without studying other topics which, although fundamental, had already received attention from different researchers in the past.

It seems advisable, therefore, to conclude this summary with a brief return to the general framework. Both a theory of technological change useful for the understanding of relatively less developed countries, and a technological policy covering the many areas which need to be tackled, undoubtedly have to go beyond the field covered by domestic industrial technology creation and must analyze in greater detail technical, economic and institutional aspects of topics such as: a) the acquisition of foreign technology, b) domestic generation of scientific and technological knowledge in areas other than manufacturing production, etc. Let us now look at some of these topics in order to put into a proper perspective the results attained by the various studies emerging from the IDB/ECLA Program.

a. Acquisition of Foreign Technology

Despite the growing importance of domestic technology creation observable in several countries in the region, there can be little doubt that most of the industrial technology in use today, as well as that which is incorporated annually into the different productive sectors, is of foreign origin and is obtained through licensing contracts, direct investment programs by multinational firms and

other similar channels. Much emphasis has been given to the markedly oligopolic character of the international markets in which the technology is so acquired, as well as to the appearance of monopoly rents arising from the uneven bargaining powers of the parties negotiating the transfer of technology. The enormous difficulties faced by the price mechanism to adequately operate in this field indicate that it is both advisable and necessary for the Public Sector to devise an optimum policy package of intervention.

Some countries have recently tried to make progress in this direction, 77/ but the failures have been by far more conspicuous than the successes. It seems reasonable to consider that, besides an administrative system for the control of technology-purchasing contracts, a more active government participation would also be required in this area, to fulfil at least two roles so far practically not covered: a) as a search agent on the world technological scenario, and b) as a centralized buyer of technology in world markets. 78/

Both courses of action would be fully justified, both from a resource allocation point of view - the centralized search would avoid the duplication of efforts and expenditure in this area -and from that of strengthening the bargaining power of the technology-purchasing countries, in so far as the oligopsonic role of the state could be seen as a countervailing force in the context of highly imperfect international markets.

b. Generation of Domestic Technological Knowledge in Non-Industrial Areas

The empirical evidence presented in previous sections indicates that in several Latin American countries the first signs are being detected of an increasing amount of domestic technological activity, in the form of adaptations and improvements to foreign technological designs and the development of new technologies on the local manufacturing scene.

77/ See in this connection: E. Aracama Zorroaguin: "Tendencias actuales de la propiedad industrial en América Latina" - Revista del Cologio de Abogados de la Ciudad de Buenos Aires, Nº 1/2, 1972.

78/ The experience of the Japanese MITI is very important in both respects. See, for example: Science and Technology Agency, White Paper on Science and Technology, several years.

It is important to note that in all cases there are - or have been - tax incentives specifically intended to encourage the undertaking of research and development expenditure. However, the briefest analysis of this field shows that the available instruments have proceeded on the basis of a very limited understanding of the technological phenomenon. 79/

Every technology creation project has a number of effects, either in terms of relative factor-saving (capital and labor), in the form of savings of foreign exchange, etc. It seems therefore important for the public authority to have a clear set of assessment criteria on the basis of which to decide upon a "portfolio" of research and development "projects" compatible with "national interests" however the latter are defined.

It is obvious, however, that no matter what tax concessions are granted to research and develpment expenditure, a wide range of very important scientific and technological problems will not be explored by the private sector, because of either their low potential profitability, the long gestational periods involved, etc. This means that a state policy for the generation of domestic technological knowledge must necessarily go beyond the granting of subsidies to the private sector, and must draw up an explicit list of research priorities to be tackled directly by the public sector, or by private institutions financed by government funds.

Almost two thirds of the Research and Development expenditure of countries like the United States, Great Britain, France or Australia, are government funded. The pattern of utilization of such funds shows a somewhat greater variation, since only 15% of overall research expenditure in the United States, about 30%in France and Great Britain and practically two thirds in Australia correspond to studies carried out by the public sector itself. 80/

79/ After a relatively chaotic period during which the Argentine Under Secretariat for Science and Technology had received no less than 2,600 requests for tax rebates on account of Research and Development expenditure, the system had to be discontinued in 1973 because of a lack of clearly defined analytical criteria which would enable such requests to be judged in the light of a national technological policy.

80/ The information comes from Science, Economic Growth and Government Policy, a paper prepared by Ch. Freeman, OECD, Paris, 1963. The Australian statistics come from P. Stubb: Innovation and Research, Institute of Applied Economic Research, University of Melbourne, Australia, 1968.

Up to now the Latin American States have shown little inclination to act as planning agents for expenditure on research and development activities undertaken by the private sector, and have merely participated passively in this sphere through indirect taxation instruments. Likewise, with regard to research carried out by the public sector itself, there has been a lack of specific scientific and technological policy guidelines, policy being limited merely to the ex post ratification of research decisions and the allocation of funds decided by the scientific and academic community.

We consider that both fields require a thorough revision of public policy and a much more active participation by the state research and university system. This implies that the government, instead of merely considering the research proposals of manufacturers and university institutes, must adopt a dynamic and regulatory attitude.

In practically all the countries in the region there are still serious problems in areas of public health, nutrition, environmental pollution, housing, transport, consumer protection, etc. - to mention only a few of the fields in which work on new knowledge creation and the formulation of new working hypotheses is most urgent. We consider that the social gains from expenditure on research in many of these fields will necessarily exceed private gain, which should provide sufficient justification for the public sector to undertake a strategy of direction, expansion and complementation of private creative activity.

Some of the topics mentioned in the previous paragraph should undoubtedly receive priority on the public sector's own research agenda, since it would be unreasonable to expect them to be covered by private sector creative efforts.

c. A New Regional Economic Order

Finally, our earlier pages suggest the possibility that the formation of a new regional scenario may already be well under way, it being feasible to predict that the largest countries in the region will fulfil a predominant role in this process as suppliers of technologically sophisticated manufactures, as well as of technology as such through licenses, direct investment etc.

It is clear that the novelty of these topics in the Latin American context is reflected in the lack of a legal and institutional framework capable of adequately regulating the movement of goods, capital and technology within the area. There is an obvious danger that the relatively more developed countries may tend to

reproduce the patterns of oligopolic behavior which they themselves had to suffer as purchasers of technology in the world market only a few years ago.

For example, at the moment only six Latin American countries belong to the group which signed the Paris Convention on Patents and Trademarks. This treaty has been strongly attacked in recent years because of the one-way protection it offers to technology-exporting countries, to the detriment of technology-importing countries. 81/

Given that it is unthinkable that such a legal framework can act as a statutory base for the growing intra-regional flow of goods, capital and technology, it is important to begin to act at the supra-national level, exploring regulatory instruments more appropriate to contemporary conditions in Latin America.

Both these subjects and those mentioned in previous paragraphs have remained outside the sphere of the studies undertaken by the IDB/ECLA Program, but there is little doubt that they all require further research in the near future.

81/ See J. Katz: Importación de Tecnología, el Tratado de París, y los países de menor desarrollo - CIE, Instituto di Tella, Buenos Aires, 1973.

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