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Domestic technological development

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A considerable proportion of the studies carried out on technical progress in Latin America has been based on the assumption —often implicit— that the technological behaviour of our societies as regards the introduction of new technical processes or products is almost entirely passive. What is more, economic theory too adopts this assumption in explaining the ways in which technical know-how is transferred from the developed to the developing countries.

The present article maintains that domestic innovative activity does exist and that many production units which are recipients of foreign technology play an active role by adapting the technical know-how received to local conditions, devising new technical variations within the limits permitted by the original technology, and creating new know-how to resolve the problems posed by the putting into operation of new equipment and the praxis of production.

The article begins by indicating the main characteristics of domestic technological development (DTD) (chapter I), and goes on to describe the typical forms or patterns it assumes under differing conditions that depend upon the line of conduct followed by entrepreneurs with respect to technology (chapter II). Some aspects of the dimension of DTD are then detailed, and an account is given of the main results achieved (chapter III). The article next discusses the problems of disseminating throughout the production apparatus the innovations and adaptations introduced by individual plants (chapter IV); reviews the conditions which economic trends impose upon the structure of DTD (chapter V); and, lastly, formulates a few reflections on the possibilities of stengthening DTD, placing the emphasis on promotion of the research and development activities (R&D) that are undertaken by manufacturing enterprises (chapter VI).

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I

Main characteristics

It would be extremely difficult to embark upon a description of domestic technological development without first fitting it into the broader frame of reference afforded by the whole subject of technological change. Its main characteristics —linkage with minor innovation, location at the level of the production unit, situation in a context where major innovations are lacking— are in fact special aspects of technological change proper to the Latin American economies.

Technological knowledge —that is, the know-how applied to productive activity— does not constitute a fixed or static stock, but is constantly being altered and increased. It is precisely the rate, pattern and origins of the additions to this stock that constitute the keynote of the theory of technical change. This theory, following in Schumpeter's footsteps,[1] regards as an innovation any change in a production function which is of the first order of magnitude. The know-how relating to this change must be 'new', and new all over the world. Schumpeter also assumes perfect dissemination of such know-how, so that it is easy to distinguish between the innovator-entrepreneur and the imitator-entrepreneur.

Thus formulated, however, the concept leaves aside a whole series of modifications of technical know-how which, although they are of 'minor' magnitude, are the result of research undertaken within enterprises, with a view to adapting and/or improving production processes and/or product designs.[2]

Thus, two types of innovation can be identified: on the one hand the major innovations which imply new production functions or important changes in those already existing or in the design of new products; and, on the other hand, the minor innovations which are incorporated in the body of improvements and adaptations introduced into production processes,

[1] J. Schumpeter, *Business Cycles*, New York, McGraw Hill, 1939, p. 94.

[2] J. Katz, *Importación de tecnología, aprendizaje e industrialización dependiente*, Mexico City, Fondo de Cultura Económica, 1976, p. 57.

equipment and/or product designs already existing. It cannot be asserted that there is a clear dividing-line between these two types of innovation, but stress needs to be laid on the existence of a set of innovations which, although thay cannot be described as completely novel or of the first order of magnitude, are likewise the result of a systematic quest whose aim is to ensure that better use is made of the available stock of technical know-how.

Analysis of the technological behaviour of production units reveals the virtually permanent existence of a group of activities whose purpose is to adapt the techniques in use to the specific conditions characterizing production at any given time. The process to which these activities give rise, and which we are calling here DTD, generates minor innovations which make the aforesaid adaptation possible, and, furthermore, tend to step up the performance of the original techniques, raising the productivity of equipment, saving inputs and perfecting product designs and standards of quality.

Thus, within the industrial complex, a group of activities —DTD— takes shape, which, as we shall see, is related to the content of such concepts as 'entry into operation' of a plant, shop-floor technical assistance, 'learning curve' generated in the praxis of production, research and development, etc. In the conditions proper to the Latin American countries, DTD results, as already shown, in the adaptation of the existing technology and the generation of minor innovations, that is, such innovations as, without substantially changing production processes or product characteristics, make possible what are sometimes significant increases in productivity. This throws into relief the first of the dominant features of DTD, i.e., its close association, save in exceptional cases, with minor innovations.

A second main characteristic of DTD, namely, its location within the individual plant, comes to light when the source of technical progress in the production unit or at the level of the firm is investigated. Admittedly, important technological changes in local plants stem from the introduction of imported technologies which involve major innovations. These technologies are brought in mainly through their incorporation in the capital goods purchased or in new product designs, or through the use of licences. On the other hand, the solution of the problems posed by the assembly and operation of the production unit, which emerges out of such tasks as those already mentioned (shop-floor technical assistance, adaptation to the characteristics of inputs and labour, adjustments in product designs according to the specifications of demand), also results in a form of technical progress linked to minor innovations whose source is in domestic technological development. In other words, DTD is located within the plant inasmuch as the aim pursued is to resolve problems arising out of the technical operation of the plant itself or problems of external origin by which its operation is affected. The fact that DTD takes place in the production unit and is closely connected with its operational problems is another of the main characteristics of this activity.

There can be no doubt that between the two forms of generation of technical progress there are broad areas of complementarity. For example, the work of assembling new equipment and putting it into operation is sure to be accompanied by tasks of adaptation and improvement, and in turn the experience deriving from management of the production process widens the range of options for the selection of new technologies.

But it may also be possible for these two forms of generation of technical progress to take each other's place. An accumulation of minor innovations may give rise to a significant change in the original production function, even though the intention behind the activities included in DTD was not that of generating a major innovation.

Attention has been drawn so far to two main characteristics of DTD: it takes place in manufacturing plants and it results in minor innovations. Later we shall add other characteristics when describing the forms it assumes, but the features mentioned are those that individualize it within the process of technological change.

However, a third characteristic may be added here. Save in a very few exceptional cases, this kind of development occurs, in Latin

American conditions, in a setting where major innovations are not common. This is why the analysis of DTD becomes particularly meaningful when the subject of technology in developing countries is under consideration.

Of course, minor innovations play their part in technical progress in the developed countries; there are even studies which quantify the far from slight importance attaching to them in the evolution of productivity in certain branches of industry.[3] But these minor innovations occur concurrently with the major innovations that become the most outstanding feature of technical progress, to which preeminence has been given by economic theory and empirical studies in the countries concerned.

II

Forms taken by domestic technological development

The image of an industrial plant that is formed at first glance may give a misleading impression of its nature. In every plant, at any given moment, there is a fixed composition of production equipment, a structure of labour skills, a production layout, a specific range of products offered on the market, etc. In this sense, a static view of the plant is correct, and each of the elements mentioned may remain constant for a more or less lengthy period. Moreover, this does often happen, and the plan will operate efficiently in so far as no change in external circumstances takes place to compel it to alter some of the elements in question. A variation in labour or input costs, a change in the determinants of demand, a reduction in the costs of competitors, are some of the exogenous factors which may conduce to a change in the former static situation of the plant. If the firm does not react intelligently in face of these factors it will lose some of the efficiency it has gained.

But there are factors within the plant, too, which make for changes in the *status quo*. The experience gathered in the production process itself may point to new ways of improving productivity, reducing costs, making more efficient use of inputs, etc. Fortuitous circumstances such as damage to machinery may mean that in solving the problem thus created a better situation is reached than existed before. Again, as a result of the incorporation of additional equipment consideration may be given to the possibility of changes throughout the production process. The know-how which is generated as the internal modifications necessitated by changes in the above-mentioned factors are put into effect is yet another source from which proposals spring for altering, adapting, improving, etc.

In this latter sense an industrial plant may be held to have a dynamic nature, or at least to display dinamic qualities, disregard of which jeopardizes the economic future of the enterprise or dooms it to operate with only mediocre results. It is precisely in the framework of this dynamic aspect of the industrial entreprise that the domestic technological development which we are describing and analysing has its place.

This development assumes diverse forms or patterns, sometimes differing widely from one another, but having in common the generation of technical know-how. The way in which they vary depends upon the causes that act as a spur to the creation of such know-how and upon the line of conduct adopted by the firm in face of these causes. That is why, when an attemp is made to classify the typical forms taken by domestic technological development, entrepreneurial behaviour becomes a major factor in defining the elements of such a classification. The one presented below makes no claim to be exhaustive but is intended rather to indicate the

[3] In this connexion, see two studies which underline the importance of minor innovations in the United States: S. Hollander, *The sources of increased efficiency*, Cambridge, Massachusetts, MIT University Press, 1965; J. L. Enos, "A measure of the rate of technological progress in the petroleum refining industry", *Journal of Industrial Economics*, Oxford (UK), June 1958.

varieties of DTD and to amplify the description of it offered here.

The *first* form it may take is proper to the task of installing capital equipment and putting it into operation. In such cases it commonly happens that the operation of this equipment has to be adapted to specific environmental conditions different from those prevailing in its country of origin. It must be borne in mind that both the technical specifications of the equipment and the layout of the plants are generally highly standardized, and any variation in local conditions with respect to those of the country of origin (climate, quality of inputs, technical level of the labour force, market size, range of final products, etc.) make adaptations necessary which are ultimately reflected in modifications of the imported technology.

It may often be noted that when a plant is installed it does not attain the output levels indicated in the engineering blueprint, largely because, as has already been pointed out, these plant designs are not adapted to local conditions and the firm's knowledge of the production process being installed is imperfect. After a time, by means of creative and adaptive technical work, the plant may approach the projected production capacity and even exceed it, if local conditions so permit and if intelligent use is made of the advantages they may offer.[4]

Among the examples that might be cited in this connexion, perhaps the most representative is the installation and inauguration of the blast furnace at the USIMINAS steel mill (Belo Horizonte, Brazil). During its first fifteen months in operation work had to be done, on the one hand, to adapt the operation of the blast furnace to the qualities of the coke and iron ore, which did not match the conditions assumed in the original design, and on the other hand, to reduce requirements of these inputs per ton of iron produced.[5]

The modifications and minor innovations to which the above-mentioned activities give rise, as well as the know-how gained by the engineering cadres in putting them into effect (learning curves) differ according to the type of contract under which technical designs are acquired and the characteristics of these; the method of purchasing equipment, i. e., as an 'open package' or by the 'turn-key' system; the calibre of the local engineering cadres, etc. When equipment is purchased as an 'open package' the technical know-how obtained is greater than in the case of a 'closed package' and the technical cadres of the plants become better prepared for operating them. Moreover, when an 'open package' is purchased, it falls to the technical cadres to take decisions on many aspects of basic engineering and engineering detail, before the equipment is installed, and in this connexion they have to put into practice the know-how accumulated in dealing with production problems. All this results in a much more profitable technological exercise than can be derived from a single 'closed package' purchase.[6]

The obvious inference is that a preference for one or the other system largely depends upon two main factors: on the one hand, upon the experience accumulated by the firm undertaking investment in industrial production; and on the other, upon labour market prospects in respect of the technicians and skilled workers required. In countries with little industrial experience there is a propensity to purchase by the 'turn-key system', above all in the case of branches of industry which do not already exist in the country, or are only in an incipient stage. This tendency is also observable in the more advanced countries of the region, however, in

[4] See J. Katz, *Creación de tecnología en el sector manufacturero argentino*, IDB/CEPAL/IDRC/UNDP Research Programme in Science and Technology (henceforward referred to as the IDB/CEPAL/IDRC/UNDP Programme), Buenos Aires, 1976, pp. 8-11.

[5] See C. Dahlman and F. Fonseca Valadares, *From Technological Dependence to Technological Development. The case of the USIMINAS steel plant in Brazil*, IDB/CEPAL/IDRC/UNDP Programme, Buenos Aires, 1978, pp. 129-139. In reality, the case of USIMINAS is representative of a firm whose technological activities embrace all the typical forms of DTD reviewed here; the last of these (R&D) has even acquired such great importance in this enterprise as to enable it successfully to tackle problems proper to the other forms.

[6] For a discussion of the relations between types of contract and learning curves of design engineering cadres on the one hand and plant engineering cadres on the other, see F. C. Sercovich, *Desarrollo de la capacidad de ingeniería en el sector químico-petroquímico. Delimitación metodológica de un campo de estudio*, IDB/CEPAL/IDRC/UNDP Programme, Buenos Aires, 1977.

plant incorporating new technologies very different from those already familiar, or when the entrepreneur sets much too high a value on the guarantees offered by the enterprises selling the plant, even at the risk of increasing his degree of dependence upon these firms. The choice is also affected by the financing facilities extended by the suppliers, who may propose more advantageous terms for a turn-key purchase.

A *second* form or pattern also derives, like the foregoing, from an explicit decision on the part of the entrepreneur with respect to the alternative of renewing his capital equipment, and therefore introducing new technology, or improving the existing equipment by the adoption of changes with a view to raising productivity, increasing the volume of output or offering new products, without replacing equipment on any considerable scale. In this latter case, a form of DTD will be involved that implies important technological activities, to cope with which the firm must have accumulated experience and followed through a learning curve conceivable only where a quite high degree of industrial maturity exists. The factors which would incline an entrepreneur to tackel this second form of domestic technological development are, *inter alia*, the relative prices of capital and of specialized manpower (necessary for the adaptations and improvements to be carried out), and market uncertainties over the medium term.[7] For example, the Argentinian cigarette industry, during the period 1966-1976, opted for the introduction of improvements in its equipment rather than the purchase of new machinery. Apart from the factors indicated, the low rate of return that this branch of industry was obtaining, as well as the stringent restrictions imposed on imports of equipment, were responsible for this decision.[8]

The form of DTD just described stems from an investment decision. The entrepreneur, in order to attain a specific production capacity, opts for introducing improvements in his equipment instead of replacing it or putting out new products.

A *third* proceeding also includes among its results the introduction of changes in equipment or in products, but basically derives from a decision to secure an overall reduction of plant costs. Among the factors immediately underlying this form of DTD are the behaviour of competitors, a rise in the prices of certain inputs of key importance for the production process, or a relative shortage of certain supplies or of technicians and skilled workers.

A *fourth* type of DTD consists in activities which represent a response to operational problems arising when the plant has reached the stage of normal operation. They may be undertaken for a wide variety of causes: changes in the product market, alterations in inputs, technical problems connected with the maintenance of the equipment, etc. Many of these activities are of the type termed shop-floor technical assistance, and, generally speaking, they mean almost permanent work for the engineering cadres that are responsible for keeping up or raising the plant's level of output.

In the rayon factory belonging to the firm of DUCILO S.A., in Argentina, these shop-floor technical assistance activities resulted in significant increases in productivity. Increases in spinning speed (in response to the expansion of demand) and in the average denier of the yarn accounted for two-thirds of the rise in labour productivity in the factory during the period 1941-1967.[9]

In the steel-making firm of ACINDAR, also in Argentina, 75% of the projects in a representative sample of the enterprise's technological activity in 1970-1974 were found to be of this type, since they were motivated by specific market requirements, by shortages in the supply of raw materials, by production problems deriving from difficulties with the proces-

[7] See A. Canitrot, *Un esquema para evaluar la significación de las variables microeconómicas en el análisis de decisión de incorporación de tecnología*, IDB/CEPAL/IDRC/UNDP Programme, Buenos Aires, 1977.

[8] See J. Fidel, and J. Lucángeli, *Costo y beneficio de distintas opciones tecnológicas en el marco de un oligopolio diferenciado: el caso de la industria del cigarrillo*, IDB/CEPAL/IDRC/UNDP Programme, Buenos Aire, 1978, pp. 19-21.

[9] See J. Katz *et al.*, *Productividad, tecnología y esfuerzos locales de investigación y desarrollo* IDB/CEPAL/IDRC/UNDP Programme, Buenos Aires, 1978, p. 31.

ses in use, and by defects in the quality of the end product.[10]

In the Latin American countries with the strongest industrial tradition this shop-floor technical assistance is very common, and is usually the most representative form of domestic technological development. A point to note is that it does not depend so much as the preceding forms on explicit entrepreneurial decisions in face of exogenous circumstances, but rather upon the force of circumstances within the plant. In so far as the enterprise is capable of undertaking these activities a technological 'learning curve' is gradually generated which is essential for the performance of other tasks, such as those comprised in the preceding forms of DTD.

The patterns described up to now relate mainly to changes in process techniques, but undoubtedly similar situations may arise in connexion with product technology. Thus a *fifth* form of domestic technological development appears, linked to the characteristics of the products with which the factories supply the market. The activities which this form of DTD comprises are generally prompted by the requirements of demand: quality, durability and performance of products, introduction of features which make them more attractive to consumers, adaptation of designs from abroad to local consumer conditions and habits, etc. These activities, however, imply not only the modification and adaptation of the article produced, but also adjustments in the production processes which will increase in magnitude commensurately with the importance of the changes introduced in the products.

Lastly, a *sixth* form of DTD consists in explicit 'research and development' activities. This kind, the least frequent in the region's manufacturing sector, takes in and draws sustenance from the experience gathered through the forms of DTD previously described; at the same time, however, it is not entirely dependent upon the contingencies of the production process, or upon market conjunctures, but undertakes tasks on a systematic basis for the purpose of increasing the stock of scientific knowledge and technical know-how and using it in devising new applications.[11] A significant change in the characteristic of the end products of the plant, an improvement in important aspects of the production process, or the creation of new products or processes, are proper to this type of technological development. One of its basic characteristics is that it operates in such a way as to make it possible to systematize the know-how generated through the forms of DTD described above, and also to obtain generally applicable knowledge. The innovations to which it gives rise are consciously sought for their own sake, instead of resulting from activities linked to the expansion of production, to problems of plant operation or to the market circumstances of the moment. It must be stressed, however, that, as already stated, this last form of DTD is not independent of the others either. The staff of research and development departments in industrial establisment are in close touch with production activities, and an interchange of technical personnel often takes place between what might be termed the sphere of production and that of research. What really matters, where this form of DTD is concerned, is the existence of permanent research and development activities within the plant, which undoubtedly implies a special entrepreneurial decision in the technological field. Such a decision involves explicit considerations as to the technological future of the enterprise, reveals competitive drive, and above all shows that a high value is set on the role of technical progress in the economic performance of the firm. These research and development activities are conducted by teams which are closely linked to the plant, or which may also be set up as firms of engineering consultants not only serving the plant to which they are attached but also selling services to others, and thus adding a new economic dimension to the enterprise.

The foregoing description of the typical

[10] See P. Maxwell, *Implicit R&D Strategy and Investment-Linked R&D. A Study of the R&D Programme of Argentina Steel Firm, ACINDAR S. A.*, IDB/CEPAL/IDRC/UNDP Programme, Buenos Aires, 1978, pp. 23-30.

[11] For a precise definition of the concept of research and development, see C. Freeman, *The Economics of Industrial Innovation*, Harmondsworth, Penguin Books, 1974, Appendix A, pp. 311 *et seq.*

patterns followed or forms assumed by domestic technological development suggests that they constitute a sort of sequence extending from those associated with installing equipment and putting it into operation to those which call for a quite high degree of maturity in the branch of industry and the producer plant concerned. The various forms of DTD do not necessarily appear in the sequence indicated, for the different activities they involve may be simultaneously carried on. For example, shop-floor technical assistance is an almost permanent activity, pursued alongside others; those arising out of the introduction of new capital equipment determine the need to make changes in the more old-fashioned equipment which remains in use.

The remodelling of equipment as an alternative to purchasing new machinery, and the adjustments made with a view to reducing plant costs, imply similar technological activities, the results of which in many cases serve both ends. In practice, as already stated, the forms assumed by DTD are differentiated not so much by the type of activity they entail as by the firm's behaviour in face of specific problems.

Nevertheless, the above-mentioned sequence is consistent with noteworthy empirical observations relating to the plant's accumulated stock of production experience and to the calibre of its technical cadres. In so far as the stock increases and the calibre improves, more and more complex tasks of technological adaptation and creation can be attemped, and, moreover, the firm will be in a better position to select the technologies to be incorporated.

The handling of 'packages' of technology and the conduct of systematic research and development activities would be a difficult matter in an economic milieu with little industrial experience, where firms are just embarking on production and there is no adequate supply of technical personnel to form experienced engineering teams. While the activities carried out in the field of adaptation and generation of technology may simultaneously pertain to several of the typical forms of DTD described, their quality and technical level will, in most cases, be conditioned by the degree of maturity not only of the plant but of the branch of industry to which it belongs.

III

Dimensions and results of domestic technological development

Out of the set of elements and typical features so far incorporated in this sketch of the nature of domestic technological development, we are going to concentrate attention, for the moment, on the one which characterizes it in the context of underdevelopment. It should be stressed, from the outset, that DTD is not inherent in any and every situation of underdevelopment. Logically, for it to exist on a reasonable scale, the country's industrial sector must not be too small, although neither enclaves thal possess, in our opinion, a technological process peculiarly their own, which evolves within the enclaves themselves and on which the conditions prevailing in the country have only a very slight impact.

Setting aside these two situations, there remains a category of countries in which the development process has been accompanied by a correlative growth of the industrial sector, with degrees of maturity that vary from one country to another, but all sharing the common feature of great technological dependence on the developed world. These may be described as countries in which industrialization is belated, that is, which have only recently attained a stage of industrial development that was reached some decades ago by Japan, Italy, etc.,

while these in their turn lagged behind the United Kingdom and the United States in this respect. The chief difference, as regards technology, between the belatedly industrialized countries and those of the rest of the underdeveloped world lies in the fact that the latter have not yet arrived at the stage in which, concurrently with the introduction of foreign technologies, domestic creative capacity is to be found. Among the Latin American countries, it may be asserted that Argentina, Brazil, Mexico and Colombia at least have sufficient capacity to generate an internal flow of technological know-how complementary to imported technology.[12]

In these countries, therefore, domestic technological development has acquired a dimension much greater than is attributed to it in various studies on the problems of the region. Most studies of this kind focus their attention on the effects of the absorption of foreign technology on our economies, since what they generally analyse is the impact of major innovations on employment and domestic capital accumulation. Various investigations show that domestic technological development is thriving, at least in the more industrialized countries of the region. The capacity for adapting foreign technology and the changes which this undergoes through the introduction of minor innovations afford a whole range of interesting results with respect to the generation of learning curves and the consequent improvements in the shop-floor technical assistance and research and development cadres, as well as in the technical level of local engineering groups.

A first point worth noting is that expenditure on research and development is acquiring increasing importance in the context of the scientific and technological systems of these countries. In Mexico, such expenditure, which covers both basic research and applied research and experimental development, rose from 0.06% of the gross domestic product in 1964 to 0.03% in 1976.[13] A similar increase is to be seen in Brazil, where resources earmarked for scientific and technological development activities soared from 440 million cruzeiros in 1970 to 6,840 million cruzeiros in 1975 (at constant prices).[14]

The aim pursued here, however, is not to analyse the creation of know-how in the context of a national scientific and technological system, but merely to show the dynamism that it is acquiring. If innovative activity within manufacturing industry in the above-mentioned countries is examined, it will also be seen that the firms' expenditure on technological research and development is considerable, and is positively associated with increases in labour productivity.

On the basis of a field study of a sample of 200 establishments in Argentina, it was estimated that in 1968 enterprises as a whole had expended about 33 million dollars on engineering activities and on other associated technical work. In turn, it was shown that the growth rate of productivity was statistically linked to accrued expenditure on domestic R&D.[15]

Similar conclusions are reached in another study relating to manufacturing industry in Colombia.[16] This study, based on a sample of about 90 enterprises, shows that in some sectors (metal-working and electrical apparatus industries) outlays on research and development amounted to more than 2% of the value of sales, and it also finds a significant statistical relation between research and development expenditure and increases in productivity.

By virtue of the firms' deliberate efforts, and of the learning curve implicit in the work of production, a domestic technological capacity is gradually generated which is reflected in the improvement and adaptation of processes and/or products and makes it possible to improve upon the performance of the original technol-

[12] See J. Katz, *Cambio tecnológico, desarrollo económico y las relaciones intra y extra regionales de América Latina*, IDB/CEPAL/IDRC/UNDP Programme, Buenos Aires, 1978, pp. 7-9.

[13] See Alejandro Nadal Egez, *Instrumentos de política científica y tecnológica en México*, El Colegio de México, 1977, pp. 22-25.

[14] See Office of the President of the Republic, *II Plano Básico de Desenvolvimento Científico e Tecnológico*, Brasilia, 1976, pp. 27-31.

[15] See J. Katz, *Importación de tecnología, aprendizaje e industrialización dependiente*, *op. cit.*, pp. 97-101.

[16] See M. Ramírez Gómez and D. Sandoval Peralta, *Tecnología en el sector manufacturero colombiano*, IDB/CEPAL/IDRC/UNDP Programme, Buenos Aires, 1978.

ogy. In those plants in which modifications have been introduced in processes over a long period of time through adjustment of equipments to changing technical and economic conditions, a technological profile emerges that differs from the original design and may in some cases come to be regarded as a new design, with significant advantages in view of the conditions prevailing in the local milieu. This explains, albeit only in part, the correlation observed between the technical capacity evolving in consequence of this domestic technological development and the successes achieved by several Latin American countries in exports of manufactures, 'turn-key' sales of plant and exports of industrial engineering designs, although recognition must also be accorded to the important role played in the promotion of such exports by subsidies and other economic policy measures (exchange rate, credits, etc.). It should also be pointed out that the great majority of these external sales have been made to countries in the region and to others with characteristics similar to our own.[17]

From the foregoing paragraphs it can be seen that the research referred to has shed light on the existence and order of magnitude of domestic technological development and has probed into the scope of its potentialities. All this research has pivoted upon microeconomic studies, examining DTD from within the firms or factories: an approach which has permitted a detailed breakdown of it with a view to understanding it more fully. Furthermore, as a result of these studies there has been some speculation on the manufacturing sector's prospects of progress in the field of technology and the effects of this on the development of our countries. According to these conjectures, the more advanced countries of the region have possibilities of generating technological flows to complement —and also to take the place of— imported technology which put them in a position to increase domestic productivity, step up exports of technology incorporated in consumer and capital goods, and compete, in certain areas of the international market, in the field of engineering designs.[18]

In short, this domestic technological development produces results which are closely linked with the economic growth of the countries concerned. The role played by DTD in increasing plant productivity and in adapting products and processes to local technical and economic conditions, its influence on the possibilities of exporting manufactures and even technology, the fact that it acts as a mechanism for improving skills and that it generates know-how which facilitates the selection of the technology to be incorporated, etc., are eloquent testimonies to its importance as a positive factor in economic growth.

In this context something may usefully be said of the effects of DTD on two important aspects of industrial development: the characteristics of the technological profile which is shaped by the adaptive and creative activities mentioned above, and their incidence on the absorption of labour.

As regards the first aspect, the question is whether DTD succeeds in altering the basic characteristics of the original technology. This point is of importance in so far as imported technologies are not felt to be the best suited to conditions in developing countries. To put it another way, does domestic technological development influence the shaping of the technological profile of manufactures by changing the profile derived from technologies incorporated from abroad? Although there are examples to show that this is what has happened in some cases, it is difficult to formulate a general and conclusive opinion on the subject.[19]

[17] See J. Katz and E. Ablin, *Tecnología y exportaciones industriales: Un análisis microeconómico de la experiencia argentina reciente*, IDB/CEPAL/IDRC/UNDP Programme, Buenos Aires, 1976; and 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*, IDB/CEPAL/IDRC/UNDP Programme, Buenos Aires, 1978.

[18] See J. Katz, *Cambio tecnológico, desarrollo económico y las relaciones intra y extra regionales de América Latina, op. cit.*

[19] The studies carried out on technological change in the cigarette industry in Argentina show that 100-mm and 120-mm cigarettes are produced with third-generation equipment in which adaptations and minor innovations have been introduced, whereas in the developed countries production of such cigarettes calls for equipment incorporating more recent technologies. Thanks to these adaptations and minor innovations, too, significant increases have been recorded in the productivity of both machinery and

Again, adaptive and innovative activities in the Latin American countries tend to recognize the market as an important determining factor and consequently they may be said to generate technological profiles more in keeping with real conditions in the region. But, on the other hand, these activities, which are carried on within each production unit, are also a response to the special needs of the individual plant, such as, for example, more efficient utilization of the stock of machinery it already possesses, or adjustment of the production process to the conditions imposed by installation of new equipment in some of its stages. If the technological profiles which factories are thus gradually acquiring are viewed in the aggregate, the resulting profile for the manufacturing sector as a whole is difficult to predict, and need not necessarily represent an advance towards the solution of certain basic problems posed by the industrial development of the Latin American countries. For example, it can hardly be guaranteed that during a cycle of very brisk domestic technological development any significant change will take place in the employment situation in the manufacturing sector.

There is evidence that the adaptations and minor innovations which are incorporated into capital equipment have the same labour-saving bias as is characteristic of the original imported technology; that is, the labour required per unit of output after a period of adaptation is less than was needed with the original equipment. But employment per unit of output when the remodelled version of the older technology is used generally exceeds what is necessary (also per unit of product) with equipment incorporating the most recently generated technology.

The labour-saving bias of minor innovations produces less effect than would the introduction of new foreign technology. A case in point is described in a study on cotton-spinning mills in Argentina. Three different technological situations are analysed. The first corresponds to spinning mills with capital equipment dating on average from the period 1948-1955. In the second, the same equipment is used, but after the introduction of a series of improvements and adaptations. The third is the case of a plant with 1970-1972 technology. The study shows that for the same volume of output of similar-quality yarn 32% less manpower was employed in the second situation than in the first. If in turn the third situation is compared with the first, the saving of labour amounts to 60%.[20]

It would seem, however, that more thorough studies must be made on the relations between the results of domestic technological development, the effects of the incorporation of modern technology, and employment.[21] Carrying out such studies in greater depth does not seem likely to invalidate the general presumption as to a labour-saving bias, but, in our opinion, it needs qualifying. It is presumed that the results of DTD activities imply, in principle, greater absorption of skilled technicians

labour. See J. Fidel, J. Lucángeli, and P. Sheperd, *Perfil y comportamiento tecnológico de la industria del cigarrillo en la Argentina*, IDB/CEPAL/IDRC/UNDP Programme, Buenos Aires, 1976, chapter V. An analysis of the technological evolution of the Acindar rolling mill for finished steel products (Rosario, Argentina) shows that after it had been installed for twenty years changes in the engineering design were introduced which made it possible to increase capacity by 70%, and to manufacture a more diversified range of products to serve the motor-vehicle industry. See P. Maxwell, "Estrategia tecnológica óptima en un contexto económico difícil. La evolución de la planta siderúrgica de Acindar en Rosario, Argentina". *El Trimestre Económico*, No. 180, Mexico City, October-December 1978. The Mexican firm Furfural y Derivados S.A. developed a process for obtaining furfural (raw material for producing certain types of alcohol), by introducing changes into the process used in Finland and the United States, and thus created a technology which it exports under its own patent. See L. A. Pérez Aceves and J. J. Pérez y Peniche, *Análisis microeconómico de las características del cambio tecnológico y del proceso de innovaciones. El caso de Furfural y Derivados S.A., México*, IDB/CEPAL/IDRC/UNDP Programme, Buenos Aires, 1978, pp. 7-14.

[20] See A. Canitrot, J. Fidel, M. Juillerat, and J. Lucángeli, "El empleo en la industria textil argentina. Análisis de comportamiento y de elección tecnológica", *Desarrollo Económico*, vol. XVI, No. 63, Buenos Aires, October-December 1976.

[21] In this connexion, it is worth while recalling the singular behaviour of the construction industry in Argentina. Between the years 1950 and 1973 its labour productivity showed a slightly declining trend, which implies —in terms of employment— that in this sector in 1973 one unit of final output generated a level of employment slightly higher than it would have done in 1950. Much the same thing happened in the Mexican construction industry between 1950 and 1965. See G. Vitelli, *Cambio tecnológico, estructura de mercado y ocupación en la industria de la construcción argentina*, IDB/CEPAL/IDRC/UNDP Programme, Buenos Aires, 1978, pp. 1-4.

and specialized operatives, and a relative decrease in employment of unskilled workers. What would have to more carefully investigated is the possibility of quantifying the relation between a change in the technological profiles of manufactures and the composition of industrial employment by levels of skill.

With the backing of a study of this type, one would be in a better position to evaluate the 'impact' of the evolution of technological profiles on employment and to draw conclusions as to the magnitude of these effects. Needless to say, the research implicit in this approach is closely linked with the efforts that are being made in many countries and study centres to work out criteria for the guidance of policies relating to the training of skilled manpower at the various levels.

IV

Transferability of minor innovations

Lastly, all that remains to complete the analysis of the nature of domestic technological development and its main characteristics is to pass in brief review the problems raised by the dissemination of its results.

The transferability and dissemination of the results of innovative activity is a topic of importance in theoretical approaches to technical progress. It is precisely the greater or lesser dissemination of this progress that is linked up with its repercussions on a country's industrial development. If its dissemination were perfect, as is theoretically conceivable, and were to cost nothing, the social yield of innovative efforts would be maximized, and so would their impact on the growth of productivity and on competitive market conditions. But this very seldom happens; the know-how generated by innovative activities does not flow freely between firms and countries and, as will be shown, it is real market and production conditions that obstruct the flow. Dissemination of the results of domestic technological development encounters even greater difficulties, particularly where minor innovations in processes are concerned, although a greater degree of transferability can be expected when such innovations relate to products.

This topic should be studied in the broader framework of technological dissemination, with reference to some of its theoretical aspects. A point to stress from the outset is that technological know-how has the character of a 'public good',[22] which means that the design of a production process or of a product can normally be used by an unlimited number of individuals, without this implying that its usefulness is thereby exhausted. From the social standpoint, it is undesirable for new know-how not to be disseminated, since the marginal social cost of its use is, theoretically, equal to zero except for the costs incurred through its adaptation. Consequently, imperfect mobility of know-how would prevent a society as a whole from succeeding in optimizing its economic behaviour.

The transfer of the results of technological activities depends upon the benefits obtained both by the supplier and by the purchaser. The greater the benefit ensured both on the supply side and on the demand side by the dissemination of know-how, the greater will be the mobility that may be expected. Presumably, if the purchaser pays a given price for the know-how in which he is interested he does so because he considers the benefits that he will obtain from applying it to be adequate. Accordingly, the question of transferability of know-how is more closely, linked to the supplier, that is, to the executor of the innovative effort, and to his

[22] A pure 'public good' is one whose consumption by an individual does not exclude consumption by others. See P.A. Samuelson, *The Collected Scientific Papers of Paul A. Samuelson*, Vol. II, Cambridge, Massachusetts, MIT Press, 1972, p. 1213.

prospects of benefiting by its transfer. The fact that technological know-how is a public good militates against his chances of reaping the benefits in question.

An adequate system of patents would facilitate dissemination and at the same time would ensure that the entrepreneur responsible for the innovation effort derived some profit from the transfer of the know-how to which it gave rise. The patent system, however, is meaningful only for some innovations. A considerable body of new technological know-how is not patented, in some cases because patenting it would give away valuable information to competitors, and in others because some important innovations are not susceptible of patenting (for example certain sales systems).[23] Basically, therefore, it is difficult for the entrepreneur to secure the benefits implicit in the dissemination of the results of innovative activity, unless he enjoys some degree of monopoly.

The reduction of costs through the betterment of existing processes or the introduction of new ones, and the improvement of the quality of the goods produced or the designing of new products, both enable the entrepreneur to gain advantages in the market in which he is competing, although innovations in products are easier to imitate and therefore the measure of monopoly obtained is short-lived. Hence it may be asserted that the degree of dissemination of product innovations is higher, since the profit deriving from such dissemination is harder to secure. But at all events, whether the entrepreneur makes his innovations in processes and/or in products, he is not selling know-how but products, although the nature of the market is affected by the generation of know-how.[24]

This is also the commonest way in which domestic technological development is disseminated, i.e., through know-how incorporated in products. But it must be noted that there are a number of restrictions on the local entrepreneur's transfer of know-how, and therefore on the chances of increased mobility of the results of local innovative activity.

The task of solving the operational problems that arise in a plant, the need to adapt it to changing market or input conditions, the adjustments that have to be introduced in equipment, when some items with new technological contents are brought in as replacements, etc., generate learning curves in the engineering cadres and give rise, as was said before, to improvements and innovations in production processes and in products. But this know-how which emerges out of innovative activity localized in a plant is usually of a very specific character, centering upon each plan's special conditions, and therefore cannot easily be disseminated or transferred to other similar plants.

Even in cases where dissemination of the type of know-how generated in the plants is possible, it would be discouraged by the market structures prevailing in the manufacturing sector. If it is assumed that the bulk of local innovative activity takes place in medium-sized and large enterprises and in markets where oligopolistic competition is very keen the dissemination of a given type of information —in so far as it is specific— would imply renouncing a certain degree of monopoly gained precisely on the basis of the firm's innovative efforts. Thus, the market structure and the degree of concentration in a branch of industry would condition the dissemination of new know-how.

However, the types of know-how which would tend not to be disseminated and, consequently, would remain within the production unit that generated them are those relating to process technologies, since those connected with product technologies can in most cases be imitated or copied by competitors.[25]

In Latin America there are enterprises which already are or could be potential suppliers of technological know-how. It must be borne in mind, however, that they are engaged in producing goods and/or services; their main activity is production, and as a general rule they

[23] See J.E. Stiglitz, *On the micro-economics of technical progress*, IDB/CEPAL/IDRC/UNDP Programme, Working Paper No. 32, Buenos Aires, 1979, pp. 9-10.

[24] *Ibid.*, p. 10.

[25] Although product designs may be legally protected, in practice this does not prevent their imitation and the launching of similar products.

are not firms whose purpose is to sell technology. The sale of technological assets calls for a technical team whose job is not only to market them, but also, and above all, to systematize the information and technical know-how developed by the firm. It is necessary to have built up out of the sum total of minor innovations a critical mass of innovations which affords economic justification for the maintenance of such teams, and which enables the enterprise to put out a 'package' of innovations for sale. In other words, the sale of technological assets is subject to the restrictions imposed by economies of scale.

The above-mentioned systematization is more feasible in cases where the production units or the firms concerned possess a 'research and development' department. These enterprises can undertake the relevant studies whereby activities to improve output or to reduce costs, or any of the other forms of DTD described, can be turned to account to provide engineering designs which can be offered on the market, either as designs proper or through technical assistance to other plants. In this last connexion, some successful experiments have been carried out in the establishment of engineering firms on the basis of the experience gathered in adaptation of technology and generation of minor innovations in enterprises in several Latin American countries.[26]

There are, of course, instances in which very marked mobility of know-how is observable. A case in point is the dissemination of information among the subsidiaries —in different countries— of transnational corporations, where know-how goes to form part of the net wealth of the enterprise as a whole. In this case too the know-how generated is usually highly specific, in response to the special conditions prevailing in the plants and in the economic and social milieu to which they belong. Although this specificity is an obstacle to dissemination, it must be borne in mind that these are subsidiaries which in the main have similar technical characteristics, just as the general conditions in which they operate are also much alike. This is not enough, however, to explain the high degree of dissemination, since it can be noted as well that factors like those described are common to plants belonging to the same branch of industry in a given country. The other circumstance that furthers an easier flow of know-how between subsidiaries is when they operate in different markets where competition is virtually non-existent; this removes one of the basic problems hindering dissemination among domestic enterprises within a single country.[27]

Similarly, interesting examples are to be found of transferability of technical know-how among firms in different countries of the region, especially in respect of steel-making and petroleum. A study carried out on scientific and technological co-operation among Latin American countries shows that the interchange and dissemination of technology exists in various forms among State enterprises and private firms. Predominant among these forms are assistance in solving plant operation problems, training of personnel, studies on selection of technology, etc.[28] It is a valid assertion, how-

[26] The Companhia Brasileira de Projetos Industriais (COBRAPI) had its origin in the Companhia Siderúrgica Nacional (CSN), where it started life as the firms's Projects Department in 1941. As the services required spread beyond the province of CSN, COBRAPI was established in 1963. The structure of the new enterprise enabled it to cover all phases of planning —basic conception and feasibility; project engineering— basic project; construction engineering and assembly. See E.M. Ford *et al., Oferta de Servicio de Consultoria de Engenharia no Brasil*, Financiadora de Estudos e Projetos, S.A. (FINEP), Rio de Janeiro, 1977, pp. 109-120; and COBRAPI, *A presentação do proponente*, São Paulo, 1977.

[27] While there are innumerable examples of assistance among subsidiaries, particular interest attaches to the installation of two cigarette factories in Bolivia, in view of the similar behaviour of two transnational corporations. Massalín y Celasco and the Compañía Nobleza de Tabacos, Argentinian subsidiaries of Philip Morris Int. and British-American Tobacco Co., respectively, were made responsible not only for setting up the plants but also for supplying modernized equipment, training personnel and supervising the work of putting the plant into operation.

[28] Mention may be made of the following cases of transfer of know-how among enterprises in the region: the technical assistance given by the Argentinian enterprise Yacimientos Petrolíferos Fiscales (YPF) to the Uruguayan Administración Nacional de Combustibles, Alcohol y Portland (ANCAP) in the conduct of seismological studies for petroleum-prospecting purposes; the training of personnel undertaken by the Ecuadorian State Petroleum enterprise in several firms in the region; and the assistance given by the Chilean Compañía de Acero del Pacífico (CAP) to Acerías Nacionales del Ecuador in the selection of technol-

ever, that the transfer of know-how between the enterprises mentioned is facilitated inasmuch as they do not compete in one and the same market, and also because they are large enterprises, many of which have very active research and development departments. Moreover, the existence of Latin American entrepreneurial associations makes it easy to disseminate information, especially as regards the technical capacity of firms as suppliers or as recipients of technological know-how.

The cases cited constitute only a small sample of an activity in which almost all the Latin American countries are engaged. The inference is that given the existence of conditions favourable to transferability and appropriate settings to facilitate it, more intensive dissemination of domestic technological efforts is possible.

Another way in which know-how is transferred is through the exporting of plant under the turnkey system or through consultant and engineering services. In this connexion the experience of the large Latin American countries, although incipient, has been promising, not only within the region but also in respect of exports to African and Asian countries. In these economies locally modified and improved technologies are better adapted to labour requirements, inputs, market sizes and product specifications than are the technologies of developed countries.[29]

The foregoing remarks on the transferability and dissemination of the results of DTD required to give it greater and more effective economic growth potential have focused attention on two main problems: development, at the level of the firm, of research work capable of systematizing and generalizing the know-how which is being generated; and the creation of conditions to make it easier for the innovator-entrepreneur to reap the benefits of this dissemination. These are not two separate problems, but are closely interrelated. They will be analysed in greater depth and possible solutions will be put forward below, when the criteria which should guide policies for fostering this aspect of technical progress are discussed.

V

DTD and economic growth conditions

Up to now we have examined various aspects of DTD which enable us to gain a more complete idea of its nature. Next we shall continue, in a sense, the same type of analysis, but changing the angle of approach. The focal point will now be the economy as a whole, or certain macroeconomic variables, instead of the individual plant, as in the first part of the article. On several occasions it has been stated that when faced with certain general conditions, not precisely defined, the entrepreneur may react by adopting particular lines of technological behaviour, and in this way the typical forms or patterns of domestic technological development have been individualized. The analysis undertaken below is, to some extent, the reverse of the preceding one; that is, the accent will be placed on characterizing these overall situations and studying their influence on DTD, so as to lead up to a series of reflections on how to strengthen the impact of DTD on technological progress in our countries.

As regards its form and intensity, domestic technological development —no longer viewed as something that emerges from the individual plant, but as a technological activity at

ogy and in the installation and putting into operation of the plant. For a more detailed analysis of the subject, see J. Fidel and J. Lucángeli, *La cooperación científico-tecnológica entre los países latinoamericanos. Su expresión en los sectores de siderurgia, petróleo y petroquímica*, Report presented to UNDP, Buenos Aires, 1977.

[29] See J. Katz and E. Ablin, *De la industria incipiente a la exportación de tecnología: la experiencia argentina en la la venta internacional de plantas industriales y obras de ingeniería*, *op. cit.*, pp. 21-29.

the level of a branch of industry— cannot be independent of the evolution of the branch in question or, by extension, of that of the sector as a whole. It may be considered that a linkage exists between DTD and the economic performance of a branch of industry, so that the two are interrelated and condition each other. It has already been pointed out, for example, that in case studies in Argentina, Colombia and Peru a close statistical association is found between the level of activity in the field of technological adaptation and generation in a group of industrial plants representative of the manufacturing sector, and the productivity of labour in the same sector. Nevertheless, the relation between DTD and the evolution of the sector and branch of industry concerned is not symmetrical. The overall conditions of the economy and those of the sector to which the branch of industry belongs have an incidence on the level and structure of domestic technological development much more important than its influence on the development of manufactures. In this sense it might be said that both in its structure and in its level of activity DTD is largely a product of the overall conditions prevailing in the economy and of those established by economic policy.

Unquestionably, the level of investment in the industrial sector is a factor of singular importance in characterizing an overall economic situation for the purposes of the analysis attempted here, since many of the activities proper to domestic technological development are operations arising out of the installation of new capital equipment or directed towards replacing its installation by adjustment or remodelling of the existing machinery. Consequently, it is logical to suppose that both economic policy and overall economic conditions affect DTD through the influence which they exert in turn on investment in manufacturing industry. Furthermore, while for the purposes of this analysis investment has been chosen as a principal macroeconomic variable, a very reasonable assumption respecting demand is also postulated. Demand and investment conditions will be similar, in the sense that an increase in the rate of investment is accompanied by expectations of a rise in the level of demand, and *vice versa*.

Let us now see how the different typical forms of DTD are related to investment in equipment, in order to establish the bases for an analysis of the relations between the behaviour of the economy and domestic technological development.

The first typical form —that occurring in consequence of the installation and entry into operation of capital equipment— is clearly a DTD activity complementary to investment. It can therefore be asserted that when the latter macroeconomic variable increases, the tasks of technological adaptation proper to this particular form of DTD will also increase, in a proportion difficult to determine *a priori*.

The second typical form —improvement of the existing equipment by means of local innovative efforts— may be considered as substitute for investment in new equipment, which generally incorporates new technology. If a comparison similar to that drawn in the preceding paragraph were to be made, we should find an inverse relationship. Similarly, the third typical form of DTD —an overall reduction of plant costs by means of modifications of the existing equipment or products— may also be regarded, in most cases, as taking the place of investment, and it will be resorted to with increasing frequency as supply conditions become more competitive.

The fourth form of DTD —shop-floor technical assistance— has no definite relation to investment, although, if it stems mainly from the need to resolve maintenance problems, it may prolong the useful life of equipment and postpone its renewal. It has already been pointed out, however, that this form includes virtually permanent activities which do not depend solely upon the age of the equipment.

The fifth form, linked to the characteristics of the products offered by firms on the market, depends more upon demand conditions than upon investment trends. And lastly, the sixth form —research and development— by the very nature of the entrepreneurial conduct that determines it, will benefit in so far as an economic climate exists which is also favourable to a brisk rate of investment and of economic expansion.

Although the foregoing description of relations between forms of DTD and the invest-

ment process is somewhat schematic, and does not embrace the indirect relations that may be detected, it does make it possible to outline a pattern of technological behaviour on the part of the firm which, in turn, will determine the level and structure of DTD.

The variables that influence the behaviour in question are closely linked to the entrepreneur's investment decision. Thus, the profitability of the new equipment, the factors of uncertainty that affect the rate of return on investment, the relation between the price of capital goods and the costs of skilled and specialized manpower and other similar items, taken together in the economic estimate, will determine the technological conduct of the entrepreneur. This will likewise be affected by the extension of the technological frontier, that is, the speed with which new innovations appear. Where this process stagnates or advances at a crawl, very hard work will be put in on adapting and improving existing equipment; and it may therefore be supposed that if the progress of technology is highly dynamic, and particularly when the qualitative changes introduced by the innovation represent very marked variations with respect to the preceding technology, activities relating to the installation and entry into operation of new equipment will develop vigorously.

Let us now revert to the discussion of relations between DTD and economic growth conditions proposed at the beginning of the present chapter. For this purpose we shall consider two kinds of situation, to which the analysis will refer. In the first place, we shall postulate a developing country with several decades of experience in industrial production, which steadily keeps up a high rate of economic growth and investment, implying in addition a rapid rate of incorporation of capital equipment with technologies of increasingly recent date. In these conditions demand too will grow at a good speed. Such a situation, in turn, sustains the medium- and long-term expectations of entrepreneurs with respect to the expansion of the economy.

Secondly, we shall assume an opposite situation: the case of a country with a slow growth rate, balance-of-payments difficulties, a low rate of investment, a sectorial composition varying greatly through time, and pessimistic entrepreneurial expectations as regards demand and overall economic conditions in the medium and long run, although, as in the preceding case, it is assumed to have lengthy experience in industrial production.

In the first situation all the typical forms of DTD may be expected to flourish. Predominant, however, will be the generation of know-how linked to the installation and entry into operation of new equipment, and the work of adaptation of existing equipment may possibly show a loss of relative importance. Impetus will be given to tasks connected with the reduction of costs and differentiation of products in so far as market competition becomes keener, although this reduction and differentiation will be achieved mainly by changing the capital equipment, when the time comes to do so, and not by adapting it. The stock of know-how and the skilled labour force built up through experience in industrial production will constitute highly important factors in the selection of the technologies to be incorporated and the design of new plants. Similarly, domestic innovative activity will gradually produce adaptations of the technologies introduced and evolve learning curves in line with the new technological profile which results from the dynamics of investment.

In the second situation, in order to maintain or expand production firms will generally need to undertake intensive reconditioning of capital equipment and to postpone the introduction of machinery incorporating more advanced technologies, since in conditions such as those prevailing in the economy the expansion of production capacities is discouraged, and the relation between prices of equipment and costs of skilled labour will be favourable to labour-intensive practices. Innovative activities aimed at reducing costs, as well as those originating in shop-floor technical assistance, will occupy a prominent place in the structure of DTD, given that, in face of the restrictions on investment, entrepreneurs will try to prolong the useful life of the existing equipment to the maximum. Undoubtedly, the forms taken by DTD in this situation show declining yields, and if they last for a long time will gradually shape a technological profile which will less

and less resemble that determined by the newest innovations. It may be said that in a case like this the technical progress of the manufacturing sector is based mainly on the know-how generated by experience and by the degree of maturity which the firms in the sector have attained, and that its dynamism will suffer from the failure to incorporate new technologies in reasonable amounts. Over the long term, this manifestation of DTD, as a substitute for the introduction of major innovations, may possibly affect the growth capacity of the sector and may have other adverse consequences such as increasingly high manufacturing costs in relation to those of a sector with a more modern technological profile. In such circumstances DTD palliates economic trends which give preference to what is known as passive investment, as against other trends in favour of active investment, i.e., those which shorten the deadlines for renewal of equipment and thus accelerate the introduction into the economic system of increases in productivity and improvements in the quality of products which are made possible by recent innovations.[30]

The analysis made so far is based on an implicit assumption which it is now time to state explicitly. It is assumed that the cost-benefit ratio of the new technology which may be incorporated into production and the cost-benefit ratio of local adaptive and innovative activities fall within a range of variability that makes them comparable, and the predominance of one or the other ratio will depend upon the prices of capital and of labour, upon uncertainty as to the future of economic growth, etc., as already pointed out. But it may happen that the technology available possesses characteristics very different from those of the equipment already installed, i.e., that major innovations are involved which give rise to a marked extension of the technological frontier, as noted before, so that this new technology can offer standards of quality and productivity far excelling those attainable with the technology it was intended to remould. This additional factor would affect the influence exerted by macroeconomic variables on the structure of DTD, as explained in the foregoing paragraphs, inducing entrepreneurs to follow the course of active investment in the branch of industry concerned, even in the second of the situations described.

VI

Conditions for the promotion of R&D activities

Throughout the analysis presented in the preceding chapter no direct reference has been made to the sixth typical form of DTD, that is, to explicit research and development (R&D) activities. This form, which, as was said before, is the least frequent in the manufacturing sector in Latin America, is closely linked, again like the others, with the overall development conditions the economy. High rates of growth and investment and expanding demand may be said to constitute essential requisites for this typical form of DTD to do well.

Here we will examine this form of DTD more exhaustively, since among its characteristics elements are to be found which would make for a change in the structure of DTD and which open up possibilities for it to bring about more radical transformations of the technological profile of manufactures than are effected by means of local adaptive activities.

It has already been pointed out that generally speaking the technical progress generated by the first five forms of DTD referred to results in what have been described as minor innovations, and stems from entrepreneurial behaviour which represents a reaction to macroeconomic incentives, to market factors or to specific production problems arising in factories. Research and development activities, however, imply a technological behaviour on the part of

[30] For an analysis of the effects of passive investment as the prevailing line of conduct in the United Kingdom and its repercussions on productivity and competition in world markets, see A. Lanfalussy, *The United Kingdom and the Six*, London, Macmillan and Co. Ltd., 1963.

firms which depends not merely upon responses to these incentives and problems, but rather upon a readiness to take risks in order to reap the future benefits of scientific inquiry and research. It has also been shown that this form of DTD permits the generalization of the know-how emerging from the praxis of production and from activities in the other typical forms, and facilitates its more mobile dissemination. All this leads us to assert that if the aim is to strengthen DTD and raise its qualitative level, to increase its influence on the evolution of the technological profile of manufactures, and even to achieve more important innovations than it has been generating in the industrial sectors of the Latin American countries, the work of research and development will need to acquire greater relative importance within DTD activities as a whole.

One of the basic objectives of technological policy must therefore directly relate to the creation of favourable conditions for the expansion of this typical form of DTD among firms in the manufacturing sector.

Many Latin American countries have instituted incentives to encourage firms to spend on research and development activities.[31] Promotion of this kind applies to specific projects which have to fulfil given conditions in order to enjoy tax exemptions or other subsidies. The extent to which enterprises have availed themselves of these possibilities differs, depending, *inter alia*, upon their size. Save in exceptional cases, however, what has been facilitated by the incentives offered is not the creation of permanent and dynamic R&D machinery, but the more or less sporadic establishment of technical groups to look for solutions to specific problems; generally speaking, these attempts at promotion have not taken into account the complexity of this form of domestic technological development. Activities relating to the creation and dissemination of technical know-how are conditioned by three main factors: the indivisibility of expenditure on R&D; the high degree of uncertainty which characterizes the process of generating know-how; and the doubtful possibility of reaping the benefits deriving from its results.

The indivisibility of expenditure on R&D means that the firm must possess a body of resources, skilled manpower and equipment which cannot drop below a certain level if experimental work is to be permanent. In other words, the firm must incorporate a mechanism which implies an additional fixed cost.

Uncertainty is inevitable, since it is part of the nature of the process of generating know-how, owing to the element of chance in the obtaining of results and the impossibility of knowing *a priori* the value of the product to be obtained. However, the longer the time required to execute R&D projects, the greater will be the risks which this uncertainty implies, and which also depend on the development conditions of the economy.

The problem of appropriability was analysed when the subject of dissemination was discussed in chapter IV, where the fact that technological know-how is a public good was shown to militate against the innovator entrepreneur's chances of reaping the benefit of the results obtained.

In a situation in which the economy is expanding steadily entrepreneurs will be readier to introduce an additional fixed cost for the purpose of creating permanent R&D machinery, and at the same time the uncertainty that affects them is largely reduced to that inherent in the experimental process proper. Technological policy ought to stop promoting sporadic action in this direction, and instead establish incentives which will lighten the financial burden which firms must assume in order to meet the requirements posed by the minimum volume of resources needed for such machinery. Otherwise, only large private enterprises —in particular subsidiaries of transnational corporations— and public enterprises would be able to undertake R&D activities, just as is the case at present. Medium-sized enterprises, unless they are exceptionally dynamic, encounter serious difficulties in tackling this form of DTD.

[31] For a compilation of incentives of this type in most of the Latin American countries, see Convenio Instituto para la Integración de América Latina (INTAL)—IDB/CEPAL/IDRC/UNDP Programme, *El marco jurídico de la innovación tecnológica en América Latina* (Legislación comparada), IDB/CEPAL/IDRC/UNDP Programme, Buenos Aires, 1976.

In Latin America there are several examples of firms that have set up this permanent R&D machinery. It would be extremely useful to ascertain in detail, on the basis of these cases, the branches of industry and the types of plant in respect of which this form of DTD is undertaken, and the factors that have fostered or hindered the evolution of local technological activities. The analysis of such elements as plant size, ownership of the firm (national or foreign, public or private), types of products and characteristics of demand, the extension of the frontier of technology, the degree of oligopoly, tariff protection, and specific economic policy would afford guideliness which technological policy could follow in order to expand this typical form of DTD.

In its approach to the reinforcement of DTD, the State should not merely make provision for subsidies or other similar ways of reducing the risk incurred by firms. It should also take direct action to facilitate R&D activities throughout the whole of the industrial sector, with special consideration for the situations arising in small medium-sized factories. In many Latin American countries there are public agencies which assign an important place among their duties to promotional activities to improve the technological level of industry, and which undertake research in the field of process and product technologies.

Systematic study of the *modus operandi* of these agencies, of their priority criteria, of the resources at their disposal, of the results obtained and of their influence on technological development in branches of industry would shed light on an important aspect of the technological policies applied by countries and would facilitate their reformulation with a view to strengthening DTD. Such a study becomes still more necessary when the aim is to raise the technological level of medium-sized enterprises, which are hardly capable, despite subsidies, of undertaking permanent R&D activities.

Taking as a whole the reflections set forth in this chapter with the object of clarifying certain problems that face economic policy for the promotion of R&D activities, we come up against a number of factors such as uncertainty, indivisibility of expenditure and the difficulty of reaping the benefit of results, to which must be added other difficulties stemming from the degree of oligopoly existing in our economies (especially the concentration of the industrial sector) and from the preponderance of transnational corporations, etc., which prevent market forces from bringing about an appropriate allocation of resources to R&D. Technological policy must therefore make provision for measures to counteract the disadvantages that the price system cannot overcome. Broadly speaking, it would seem logical to place the strengthening of DTD and the expansion of research and development activities in a conceptual framework similar to that used for dealing with incipient industry.

No reference is made here to the other forms of DTD or to the policies which might serve to promote them throughout the whole of the manufacturing sector. But the absence of explicit reference does not mean that encouragement of the activities concerned is considered needless. Underlying the whole question is the assumption that, in so far as enterprises set up permanent R&D mechanisms, all the forms taken by domestic technological development will benefit. Such mechanisms, closely linked to the plants and connected with the problems arising out of the praxis of production, are not only sustained, as mentioned above, by the results of the first five typical forms, but will also, by a logical process of feedback, have beneficial effects on the quality of the other activities, broadening their potentialities and raising the technical level at which they are carried out.