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Technological dependence and learning revisited*,**

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RESUMO

O artigo compara duas visões a respeito do desenvolvimento tecnológico nos países menos desenvolvidos (PMDs): os estudos de "dependência", que salientam as limitações de transferência internacional de tecnologia e capacidade tecnológica local, assim como os trabalhos de "aprendizagem incremental local", que enfatizam as conquistas dos PMDs. Após uma breve descrição de sua formação intelectual e de seu contexto institucional, são discutidas as semelhanças e diferenças do modo como tratam o desenvolvimento tecnológico em PMDs. Argumenta-se que apesar de complementaridades substanciais, que contribuem para uma melhor compreensão do fenômeno, diferenças importantes permanecem, especialmente quanto às consequências do desenvolvimento tecnológico de PMDs para a industrialização e a divisão internacional do trabalho, concluindo que desconsiderar os fatores cíclicos induz as duas "escolas" a equívocos nesse aspecto.

ABSTRACT

The article compares two contrasting views on technological development of Least Developed Countries (LDCs): the "dependence" studies, which stress the limitations of international technology transfer and indigenous techno-

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logical capability and the "incremental indigenous learning" works, which emphasize the achievements of LDCs. After a brief description of their intellectual background and institutional setting, the similarities and differences of their treatment of technological development in LDCs are discussed. It is argued that despite substantial complementarities, which contribute to a better understanding of the phenomenon, important differences remain, especially as regards the consequences of LDCs technological development for industrialization and the international division of labor, concluding that the disregard of cyclical factors mislead the two "schools" in this respect.

INTRODUCTION

Over the last fifteen years a considerable body of research on the technological development of LDCs has come to light. The ideas of what can be loosely called the "school of dependence" had an important influence on shaping some of the questions posed by this research and the answers it provided. More recently the theses of technological dependence have come under severe criticism [Soete (1981)] and, at the same time, a spate of new articles and books [e.g. Katz (1978); Lall (1982a; 1982b); Dahlman and Westphal (1982)] have suggested what seems to be an alternative view of the technological development of the LDCs. The purpose of this article is to reassess the two views and draw out implications for the present industrialization debate.

We begin with a brief presentation of what, in our reading, are the main characteristics of the two bodies of literature, including the intellectual interlocutors and the institutional setting of elaboration of such theories, since both have a bearing here, as in any social science production. Then, in the two following sections, we analyze in more depth the similarities and the differences between them as regards the technological efforts of LDCs and their implications for government policies and for the international division of labor.

THE BACKGROUND OF THE TWO "SCHOOLS"

Technological dependence

It is beyond the purpose of this article to try to review the many contributions (often contradictory), which make up what has been called the "dependence school,"[1] but it is important to recall the main issues at stake. To begin with, it is important to note that dependence theories were arguing against the "stages of development" theories (with their functional sociology underpinning and their emphasis on the "modernizing" role of foreign investment), which promised industrialization would come to the periphery as a "natural" result, similar to the industrialization of the "early comers." At the same time, they went against the orthodox Marxist view that imperialism was opposed to industrialization of the periphery, although they sought their own theoretical roots in the Marxist paradigm. A third interlocutor of dependence theorists, with which they held a much more complex relationship,[2] were the ideas developed by Economic Commission for Latin America (ECLA) on defense of the industrialization of Latin America during the fifties and early sixties. ECLA argued that products led to an uneven development of the world system (with the primary production economies) and to an uneven internal development of the Latin American countries, incapable of solving their problems of capital accumulation and employment. By the time dependence theory came to

[1] For analyses in English, the reader may refer to Cardoso (1977a); Bienefeld (1980); Rodriguez (1980) and Seers (1981).

[2] This applies mainly to the Latin-American authors, since Frank (1969) was deeply opposed to ECLA's theories, which he considered "bourgeois" and "reformist." The filial relationship of some dependence authors, such as Cardoso, towards ECLA can be seen in his article (1977b) where he appraises ECLAS', contributions. Precisely such heritage was criticized by more recent studies of development of capitalism in Brazil, such as Cardoso de Mello (1982), which argue that the main shortcoming of dependence theory was its inability to free its analysis of ECLA's approach to history in terms of the relationship of the Latin-American countries, overlooking thus the endogenous elements in capital accumulation and in the development of capitalist social relations.

be developed, the warnings of ECLA[3] that also spontaneous import-substituting industrialization would not be the answer to the problems of the Latin-American economies had been vindicated. In fact, dependence theory can be viewed as an afterthought of the battle for industrialization, which, by the mid-sixties, had come to seem more and more a Pyrrhic victory, in terms of internal economic, social and political equality and regards independence from external determination.

Dependence theorists asked two main questions, implicitly or explicitly: "Is capitalist development feasible in the periphery?" and "Which is its specificity vis-à-vis the pattern of development of central countries?"

Although there was agreement among the authors of the "dependence school" about the specificity of the development of the peripheral countries, when compared to the central economies, there was sharp disagreement about the growth possibilities of the former economies. Some authors [e.g. Frank (1969)] argued that such economies had a built-in tendency to the "development of underdevelopment," while others [e.g. Cardoso and Faletto (1979)] argued that, in some countries, the pattern of "associated development" offered scope for continuing the process of capital accumulation, albeit at a very high social and political cost.

The analyses of pattern of development which emerged from the phase of import – substituting industrialization argued that import of technology constituted now one of the main links of the chain of relationship which kept the economy of the Latin-American countries subordinated to advanced economies. The importance of technological link was greater for those countries which had industrialized more (e.g. Brazil, Mexico), and together with imports of capital goods, foreign finance and the industrial

[3] For a, now, classical study, see Tavares (1964). For a detailed presentation, of ECLA's theories and their criticisms, see Rodriguez (1981).

role of multinational corporations (MNCs), composed the web of the "new pattern of dependence."

In an early formulation [Cardoso (1973)], the underdevelopment of local capital goods industry and reliance on imported technology was seen as limiting the process of capitalist development of the periphery, since the Department I of such economies (the sector producing means of production) was said to be virtually non-existent there, preventing a productive complementarity required by capital accumulation and draining the dynamic stimuli to the central economies. Further research showed this to be an over-simplification: in many countries, an internal technical capability and the production of capital goods developed with the process of industrialization.

Nevertheless, the question posed by original dependence argument – the specificity of the industrial development of the periphery – and the answer provided – the difference in the industrial structure, especially the limited size and role played by the local supply of technology and means of production, remained nor only valid but influenced the considerable research on technological development performed by Government and academic substitutions. It is in this sense that we include this research in the "dependence school."

In trying to highlight the main concerns of these latter studies, we shall rely mainly on the results of the Brazilian research for several reasons. One, obviously, is convenience, but more important are features of the Brazilian economy: Brazil is one of the most industrialized of the LDCs, combining a large internal market with an aggressive export policy. Its capital goods industry is the largest among the LDCs (China excluded) and it is also one of the main LDCs in terms of investment in higher education, science and technological development. Nonetheless, there is a consensus that such investment so far has not seriously dented the industry's reliance on imported technology. Finally, since the early seventies, an extensive body

of literature on technological development and science and technology policy developed in Brazil.[4]

Some of the issues dealt with in this literature are closely related to our present discussion:

- The sources of technology used by private (foreign and local) and State enterprises: local – intra and extramural – development (especially the use of universities and research institutes) and import of technology. Such research involved not only opening up the "black box" of technology so as to understand what capabilities were, or not, locally developed and absorbed but also the rationale of the use of such sources by the enterprises. Such studies were usually conducted at the sector level, and were complemented by studies of the "scientific and technological system," especially case studies of the research institute and their relationship to the enterprises.
- The study of the role of the State. Initially motivated by the analysis of the enterprises rationale and the role of State policies in such rationale, it then developed into an analysis of the relationship between the explicit science and technology policy and the more general industrial policies, and to the study of conflicts of interest within the State and their relationship to the general pattern of development of the country.
- The implications of technological dependence in terms of foreign exchange costs, of the pattern of competition within industrial sectors and the foreign dominance of such sectors, among others.

[4] At the end of 1978, an extensive but not exhaustive survey made by the author listed over a hundred titles. See Erber (1981) for English-written translation. Of course, only part of such studies was directed to the issues of technological dependence. For a different source of inspiration see, for instance, the studies of diffusion by Araujo Jr. *et al.* (1976) and Cruz and Barros (1978).

Studies in other Latin-American countries developed along similar lines, developing a substantial body of knowledge about technological development of the region. It is thus somewhat perplexing to find authors (from outside the dependence school) saying that the literature

> concerned with the transfer of technology has treated developing countries as passive recipients of technology from the advanced countries and concentrated on the imperfections of the technology market that raises the costs of buying technology to hapless developing countries [Lall (1982a, p. 6)].

Although inspired by the issues of dependence, such analyses drifted away from the Marxist moorings of the original writers of dependence into the safer waters of mainstream economics. To some extent, the movement was a consequence of the inadequacies of Marxist theory, especially as regards enterprise behavior in an oligopolistic system. However, the institutional influence cannot be discarded, since a considerable part of such studies was either commissioned or directly conducted by Government institutions, where Marxist vocabulary and categories would be rather unwelcome (to put it mildly).

In fact, during the seventies, in several countries of Latin America [Segasti (1978)], science and technology policy gained a new status. New government institutions were established and old ones modernized, to promote local scientific and technological development, adopting measures which often went against the grain of the more general policies of the government. Although the issues of internal domination and class conflicts posed by the original dependence literature were outside the pail in such institutions, another part of the issues of dependence – the relationship between foreign and local capitals – was not. In fact, such research provided them with ammunition for justifying their existence and growth, and, at the same time, they gave the research a sometimes fruitful action-directs push. Nonetheless, this literature retained a "political economy approach," especially in the studies related to the State influence on technological development.

The "Incremental Indigenous Learning (IIL) School"

The writings of this group of authors are well known to the English-speaking readers, so we may be excused if we proceed at a greater speed. What probably are their most distinguishing traits are: (i) their view of technical change as an incremental process, and opposed to what Lall calls the "Schumpeter syndrome" (the emphasis on discontinuity and technological breakthroughs, based on research and development); (ii) they present a rich body of evidence concerning the LDCs mastery of manufacturing technology and the capability of introducing adaptations in products and processes developed abroad, based upon incremental, learning process; and (iii) they argue that such learning underlies the successes of some LDCs in exporting technology, sometimes disembodied, but, most often, embodied in relatively complex products and services and even in turnkey plants. From this latter evidence, they suggest that a new international division of labor may be emerging with the economies which have developed such technical capability finding a new relationship to the others LDCs and to the older industrialized countries, based upon their technological capability.

The evidence upon which such theories rest consists mainly of a collection of detailed case studies of enterprises carried out in several countries in Latin America, especially in Argentina, Brazil and Mexico, summarized in Katz (1978), and the studies of exports of technology by Latin-American countries [Katz and Ablin (1978)], India [Lall (1982a)] and Korea [Westphal *et al.* (1980); Dahlman and Westphal (1982)]. Such research was usually sponsored by international institutions, notably the World Bank, the Inter-American Development Bank (IDB) and ECLA.[5]

[5] Such literature is extensively reviewed in Bell (1982) from the point of view of the "infant industry" argument. Bell presents also many cases where learning did not occur, drawn mainly from Asian and African countries of recent industrialization.

Although Marx was a keen observer of the phenomena of learning and stressed their importance for industrial development,[6] the parentage and the interlocutors of the "IIL School" are predominantly neo-classical. This can be more clearly observed in the surveys they make of the literature [Katz (1978); Lall (1981, 1982a and b); Dahlman and Westphal (1982)] – e.g. the emphasis they put on the literature on "choice of technology." What is somewhat surprising is the ignorance they display of the contemporary literature on dependence, which had already shown in considerable detail the existence of local technological development in LDCs (a point developed further below). Whether this can be attributed to language barriers, to a paradigmatic parochialism or to other reason, is a moot question. It is certainly unfortunate, since this literature strengthens a part of their argument, even if it reduces some of its novelty. Moreover, it deprives the IIL literature of relevant interlocutors, which may contribute to question and to enrich their own conclusions, a purpose to which this article is but a modest step.

LOCAL TECHNOLOGICAL DEVELOPMENT IN LDCS

As mentioned above, the IIL School emphasizes the development of a technological capability in LDCs through an incremental process, described by Dahlman and Westphal (1982, p. 126) as follows:

> Firms in developing countries acquire increased technological mastery by engaging in a purposive technological effort to assimilate and adapt technology, an effort which typically takes place in relation to experience gained in production engineering and project execution.[7]

[6] See e.g. these chapters on the transition from manufacture to modern industry in vol. I of Capital and on the economies of constant capital in vol. III.

[7] "Production engineering [...] relates to the operation of existing plants. Project execution [...] pertains to the establishment of new production capacity" [Dahlman and Westphal (1982, p. 106-107)].

This conclusion is fully consistent with the findings of the "dependence" literature. In fact, from the earliest studies [e.g. Biato *et al.* (1971), for Brazil], it had been shown that local firms had developed design (basic and detailed) and manufacturing capabilities, especially for simple products, such as universal machine tools and agricultural equipment, based mainly on "reverse engineering."

The research on sectors where this mastery had been developed [e.g. Erber *et al.* (1974), for the capital good industry] showed that the local firms there tended to rely progressively more on imported technology via licensing, in the measure in which they diversified and increased the technical complexity of their production; a behavior confirmed by more recent studies [e.g. Erber (1982), for the same sector]. Although non-technical factors played an important role (e.g. preference of customers for foreign technology), the studies left no doubt there was also a discontinuity in technical capabilities behind such shift in sources of technology. In new industries, foreign technology was often used from the outset, either via licensing or foreign investment [sometimes as a joint venture, as described for petrochemicals by Araujo Jr. and Dick (1974); Silva Filho (1978); Teixeira (1982)]. In such cases a local technical capability was clearly lacking, especially where continuous flow processes were involved, requiring a complex set of capabilities, from the basic engineering of the process and the basic design of the plant, to the specification and procurement of capital goods.

Nonetheless, the dependence literature has shown that the import of technology does entail the development of a local technological capability – in fact, it argues that such capability is inherent in the dependent relationship. On the other hand, it also shows that such learning is limited, so as to preserve the dependent relationship. This should be no cause of surprise if one considers the rationale of the exporter of technology. Let us take the example of a licensor of technology of a product.

Exporters of technology have a deep-seated interest in ensuring that their customers possess some technological capability, since their earnings are usually pegged to the latter sales and because the responsibilities of licensor and licensee are very difficult to apportion in cases of failure, breakages etc., which may jeopardize the licensor's international reputation. Thus, the importer of technology must be at least able to manufacture the goods and/or operate the processes according to the specification, failing which the licensor must teach the licensee how to do it.

Moreover, in order that a product can be manufactured, all its parts and components must be specified to minute detail, and such specification must conform to the available supply of materials, parts and components, as well as to the specific production conditions of the local manufacturer. Therefore, the stage of detailed design[8] is better performed locally, where the product is to be manufactured, than abroad, where the licensor is

[8] The design of a product goes through three main stages [Asimow (1962)]. Taking a machine as an example, we have:

i. Feasibility – The design process starts from a need recognition. Such needs are then converted into the essential functions the equipment must perform and the latter expressed by specific performance requirements (e.g. capacity of containment and support). If, by confronting the resources available to the firm with such requirements and other constraints (e.g. delivery time), the enterprise decides that the equipment is feasible, it may end up with a set of feasible design concepts from which one will be chosen in the next stage.
ii. Basic design – Sometimes called "preliminary design," this is, technically, the most important stage in the design process, since it involves not only the choices of the design concept to be implemented, but also the specification of the definition of the materials, sub-assemblies and components to be used in its manufacture. The main elements which determine the competitive possibilities of a machine (technical performance cost and delivery time) are defined at this stage.
iii. Detailed design – Here the main consideration is to provide information for production as each part is drawn in detail to be manufactured, with emphasis being placed upon dimensions and tolerances.

The relative importance of the three stages of design will depend on largely the novelty of the product for the enterprise. When the product is well known to the enterprises, the emphasis is on optimization of the characteristics of the product at the preliminary design stage, the importance of feasibility increasing with the novelty of the product.
In terms of the categories of R&D, more often used in the literature on innovation, according to international definitions (e.g. the Frascatti Manual of the OECD), the feasibility and basic design stages should be included in "development," as long as the design is for a new product, but detailed design should be excluded. For a fuller analysis of the design stages and technical references, see Erber (1977).

located. For all parties, then, it is desirable that the licensee should know how to produce detailed designs.

Although manufacturing know-how and detailed design skills are a necessary condition for introducing innovations (as well as for production), they are not sufficient for purposes of innovation: basic design skills are necessary for innovation. Moreover, the mastery of the first two skills does not lead necessarily to a basic design capability: although in some products, especially mechanical products, it is often possible to progress from one to the other; in others, notably in products which perform atomic or molecular transformation, there is a discontinuity of knowledge between basic design on the one hand and detailed and manufacturing technology on the other.

Since basic design skills are not necessary for producing the goods, the exports of technology have no interest in closing such gap; quite the contrary, the teaching of such skills could foreclose a future source of revenues and even nurture a future competitor, especially in sectors (like the capital goods) where technical progress is incremental and engineering-based. The same applies to the skills for the feasibility stage of design. For sectors where innovation is not only design – intensive but also science-based, such as electronics, the transfer of technology is much more limited. The same reasoning applies to the licensing of process.

Thus, licensing does provide for learning but it is partial learning – a type of learning which, at the same time, ensures the licensor's revenues and the continuation of the relationship over time. Such technical control in strengthened by legal provisions: as it is well known, technology is not sold, but leased – the owner of the technology does not forsake the property of the technology, only allows the licensee to use it for a limited duration of time, under certain conditions, some of which may by quite restrictive (export prohibitions, tied-in imports etc.). Such legal control applies even in the absence of patents, although the latter strengthens it.

The same pattern of limited learning (or permanence of dependence) was observed in the case of foreign subsidiaries, where the patent company had to transfer a manufacturing and detailed design capability but not the others. The Latin-American literature suggests that this strategy was not only due to scale-economies in the production of technology, but also to the extraordinary profits they reaped through "technology-related" intra-firm transactions [Vaitsos (1974); Fajnzylber and Tarragó (1976)].

Thus, the literature on dependence argued that the transfer of technology between center and periphery was structurally limited on the side of the supplier of technology. Moreover, it was structurally limited on the side of the importer too. In fact, one of the main questions posed by this literature[9] was: since the local entrepreneurs were aware of such limitations (as shown by the research) and of the costs they entailed (tied-in imports, export prohibitions, threats of being ousted from the market by a subsidiary after the licensee had tested market, or having to pay for the technology in equity; at least, relinquishing the control of some important decisions), why did they not invest more in their own technology, walking, so to speak, "on two legs"?

The answer showed that many factors were at work, among which, six ranked especially high:

- The competition of foreign technology, which, being easily imported, put a high risk on attempting to develop local technology, especially where lead times were longer and costs higher, as for R&D-derived capabilities. Government policies related to foreign investment, imports of capital goods (where project financing played a crucial role) and import of disembodied technology were important determinants of such competition.

[9] See Erber (1981) for references.

- The pressure of clients, which often made the use of imported technology a *conditio sine qua non*, barring thus the possibility of developing local technology. This was observed not only for consumer but also for capital goods and engineering services, inclusive for State enterprises purchases.
- The structures of the markets where such enterprises operated, which not only placed a premium on the monopoly, but also allowed them to pass on to the customers the cost of the technology imported.
- The size of the local market, relative to the expenditures necessary to develop local technology and the lack of protection of such technology.
- The short-term horizon with which local enterprises operated, in many cases due to the lack of planning by the State.
- The political outlook of local entrepreneurs, who were more afraid of being controlled by the State than by foreign firms.

Thus, at one level of analysis, the answer was that the dynamics of economic and political forces was such that there was no incentive to the local entrepreneurs (and even less to subsidiaries of foreign firms) to develop a technological capability beyond that provided by technological transfer. This conclusion could be used to justify State intervention to foster such further development – and it often was. However, at another level of analysis, it showed that the original definition of dependence as a structural characteristic of the peripheral economy was not incorrect – technological dependence was just a facet of a specific type of capitalist development. The peripheral development, if in some cases allowed for an expanded capital accumulation, nonetheless contained such accumulation in a relationship of subordination.

The conclusion that technological dependence is just part of a specific pattern of development is also important to avoid some pitfalls of technological determinism – it is not simply by changing the degree of technological self-reliance that this pattern of development will be radically

transformed – a "naïve optimistic" approach [borrowing the apt expression from Cooper (1973)] often found in the literature. The determinants of technological dependence have to be sought nor only at the level of the lack of technical and scientific skills in LDCs (although they may be a powerful constraint in some cases), but especially at the level of the economic and political considerations which guide the action of the enterprises and of the State as regard the development of local technical capabilities. This view also lead to a reassessment of the role explicit science and technology policies may have in changing the technological dependence. When such policies not converge with the other policies (e.g. policies related to foreign investment) their efficacy is severely limited since they, alone, cannot change the pressures and inducements (some of which were mentioned above) which lead the enterprises to rely mainly on imported technology.

It is worth stressing that neither the more general interpretations of dependence nor the more policy-oriented research argued against import of technology and in favor of autarky, either at the level of the sector (or firm) or at the macro level, as it seems to be implied by some recent appraisals of technological dependence, e.g. Soete (1981). Their main concern was with the balance between imported and local technology in a dynamic setting, which, they argued, led to a structural unbalance.[10]

[10] Therefore, if one wished to use data of international payments for technology to "test" the relationship between technological dependence and growth, one should look at the ratio of imports to local expenditures on technology, instead of the ratio of imports to exports, as Soete (1981) does. A study of the former ratio would show that even those developed countries which have a deficit in their technological balance of payment spend internally much more than they import, where as the peripheral countries not only spend less (in absolute terms and as ratio of GNP) for internal development of technology but also show a much smaller ratio of imports to local expenditures. Japan, for instance, which has huge deficit in her technological balance of payment, spends internally six times as much as it imports, while in Brazil (one of the LDCs which spends more in science and technology internally while restricting payments abroad for technology) the ratio was about two. Although such data are illustrative of technological gap between central and peripheral countries, given the basis upon which such additional expenditures are made, they fail completely to capture the relationship between local and imported technology outlined above. For a more general criticism of this type of "testing" of dependence theory, see Cardoso's article on the "consumption" of such theory in the U.S. [Cardoso (1977a)].

There are substantial similarities but also some important differences between the dependence literature and IIL studies, as regards the study of technological effort in LDCs.

Both have followed the same analytical steps: opening up the "black box" of technology and looking at the determinants of firm behavior as regards the different types of capabilities which lay in the box. Both agree that there is a discontinuity in the skills required to master such technologies. Moreover, both agree that although there is some complementarity between imported and local technology, the former may have a deeply inhibiting effect upon the development of the latter, although the dependence studies have developed more fully the relationship between imported and local technology.

There is also a substantial degree of complementarity between the two analyses since the IIL very detailed case studies have carried the knowledge of learning beyond that reached by dependence analysts, and have pointed out a process of learning unknown in that literature – learning through exporting, which reverses the more usual view that learning is a condition to export [Westphal *et al.* (1980); Dahlman and Westphal (1982), for Korea]. Furthermore, the careful review by Bell (1982) of cases of learning has raised interesting hypotheses about the determinants of firm – behavior and international differences in learning. His analysis of the behavior of firms in terms of pressures and inducements to developed local technology converges with the analysis of the dependence studies. Moreover, his development of the "infant industry" argument (which space precludes discussing in the detail it deserves) has contributed to the analysis of the rationale and feasibility of science and technology policies in LDCs.

On the other hand, the analysis, at the sector level, of the dependence studies put more in focus the relationships between local technological efforts and the characteristics of demand and the patterns of competition, as well as the role played by specific State policies (e.g. the purchase policies of State

enterprises in the case of the capital goods industries). The sectorial approach also highlights the differences between sectors, pointing out the different role technology (local and imported) plays in the development of different industries and, conversely, the different role played by sectors in the technological development of the economy – a point to which we return in the next section. Within each sector, these studies show the interdependence of actions of the institutions involved foreign and national enterprises, government agencies and universities and research institutes, whereby, for instance, the entry of a foreign enterprises from commissioning studies to the detriment of local accumulation of the necessary experience.[11] This interdependence may generate important synergistic effects intensifying the use of either local or imported technology (the latter being more frequent). Thus, the studies of dependence argue for a science and technology policy (explicit and implicit) which is disaggregated at the level of sectors but, at the same time, retains an integrated approach, encompassing all the relevant institutions involved in the technological development of the sector. It is possible that the limited success of the explicit science and technology policies of Latin-American countries to foster a substantially higher degree of technological self-reliance [Segasti (1978)] may be due not only to the contradictions between the explicit and implicit technology policies, already mentioned, but also to the way in which such policies were implemented, acting only at the enterprises level, without a sectorial approach. The case of the Brazilian computer industry studied in detail by Tigre (1982) is an exception, both in terms of success of technological developments and in terms of a sectorial policy where implicit and explicit policies converge, which seems to confirm the rule.

Here we also find some agreement between the two groups of studies. For instance, they agree that the behavior of the firms has to be partly

[11] The same applies to purchase by State enterprises of capital goods and engineering services, where experience is a critical factor.

explained in terms of the policies pursued by governments (not only the science and technology policy but also more general policy) and that government protection is necessary to support the "infant" local technological effort. Both IIL [especially Lall (1982a; 1982b)] and dependence analyses agree that such protection, to be effective, must go beyond technological activities and include the products which result from such activities. Nonetheless, the dependence studies seem to have advanced more in this field of enterprises/sector/economy relationships, possibly because they were, at the outset, conceived as sectorial studies.

Therefore, combining the two groups of studies, perhaps we can be bolder than Dahlman and Westphal (1982, p. 115) when they assert that "as yet too few case studies exist for it to be possible to generalize about what determines the extent and the direction of technological effort by individual firms."

Nonetheless, there are important differences between the two bodies of research, which stem from their respective original paradigms and their institutional insertion. Such as the treatment of government policies, but are crystallized in what, at first sight, seems to be simply a matter of emphasis: while the IIL research stresses the development of technological capability in LDCs, the dependence studies lean on the limited nature of such development. That this is not a simple question of relative emphasis becomes clear when we look at how the two groups interpret the phenomenon in terms of the role played by LDCs in the international division of labor and their growth possibilities therein.

A NEW INTERNATIONAL ECONOMIC ORDER?

Dependence theory stressed, as we have shown, the trend to perpetuate the reliance on imported technology, as part and parcel of the peripheral condition of LDCs. Such imports, it was shown, involved high foreign

exchange costs, both in terms of explicit and hidden payment and in terms of export restrictions. Moreover, the pioneer study by Fajnzylber (1971) of Brazilian manufactured exports showed that the sectors which had a higher intensity of imported technology contributed little to the export of manufactures, while those sectors with higher than average exports did not import technology intensively. Thus, it concluded

> the majority of the industrial exports of the country rests upon the utilization of diffused technical knowledge. This supposes a fragile competitive position in a market, such as the one for manufactured products, characterized by the speed of innovations in products and processes (p. 196).

Therefore, the dependence argument ran, the peripheral countries cannot count on their spontaneous technological development to change their position in the international division of labor, where, by virtue of the technological dependence, their growth is partially limited. Furthermore, the dynamic of the international system and of their own economic and political structures are such that the peripheral condition of the LDCs is perpetuated.

What is probably the most original and provocative contribution of IIL studies is their suggestion that, contrary to the argument above, the technological development achieved by LDCs through minor innovations is an indicator of their dynamic comparative advantages and that a new international division of labor is emerging, in which

> the comparative advantage of developed versus developing countries will be determined not so much by skill requirements in general, but by skill inputs based on **specific learning processes which cannot be replicated in developing countries** [Lall (1982b, p. 174, original emphasis)].

In this view, LDCs,

> whose size, level of industrialization, education system and policy towards technology imports permit an independent assimilation of technology, should

> be able to gain a comparative advantage in various forms of high-skill activity where: (a) major innovations have been made abroad and are in the process of diffusion in advanced countries; (b) the necessary skills are acquired through engineering expertise gained through design and implementation of production processes and capital goods, rather than through large-scale scientific activity on the frontiers of technology; (c) the activity is not aimed at meeting changing needs of high-income, brand-conscious consumers; and (d) the technology involves large inputs of detailed design and adaptation to suit each application [Lall (1982b, p. 173)].

In such new international division of labor, the

> dividing line **does not fall by industry but by particular technologies within each industry**. This will lead to a change in the specializations of developed and developing countries: rather than concentrating on different types of industries as they tended to do till now, they will specialize in different processes within the same industries. Developed-developing country trade will, in other words, come more and more to resemble inter-developed country trade (Ibid, p. 174, original emphasis).

Furthermore, LDCs "which have built up a strong technological capability will reveal different sorts of comparative advantages in their exports to other developing countries as opposed to more developed ones." While such LDCs will export to the latter countries complementary technology services and simpler engineering products than those locally produced, they would export to the other developing countries "older, simpler or smaller-scale equipment," as well as turnkey plants, consulting services and licensing (Ibid, p. 175).

The evidence presented by the IIL studies on technology exports of LDCs[12] indicate that the dependence school certainly under-rated the niches

[12] In a recent study of Brazilian exports of manufactured products and engineering services, Araujo Jr. *et. al.* (1983) have suggest that local firms and subsidiaries of multinational corporations (MNCs) enjoy a competitive advantage in the markets of other LDCs based upon a learning process of relatively stable technologies which they are able to adapt to the specific need of the LDCs' markets.

which the past expansion of world trade and growth opened up for the more industrialized LDCs, using their limited technological mastery; nonetheless, it is important to note that the IIL studies show that the mastery achieved was not simply the spontaneous result of market forces but was greatly aided by specific State policies.

Should we then draw the conclusions that those countries which have already reached such level of technological development should rest content with it? And should the other LDCs aim simply at achieving such levels of technological mastery and gear their policies simply to that purpose?

In essence, the IIL studies suggest a positive answer to such questions.[13] Thus, Dahlman and Westphal (1982, p. 129,130) argue that

> Korea's experience further demonstrates that a high level of technological mastery in all aspects of the uses of technological knowledge is not required for sustained industrial development [...] Korea has become a significant industrial power mainly as a result of its proficiency in production.

And Lall (1982b, p. 169), led by the formers' results, makes a more general suggestion that "it may be argued that for poor countries just embarking on industrial development the acquisition of know-how rather than investments in building up know why is the most appropriate policy."[14]

Notwithstanding the past successes of the newly industrialized countries (NICs) in technology exports, the answer provided by the IIL studies

[13] Although Bell (1982) is not concerned with export performance, the evidence he presents suggests that for countries with a recent and small industrial sector the path of reaching the level of technological mastery achieved by the NICs is fraught with difficulties.

[14] Dahlman and Westphal (1982) qualify this at the end by saying that "the objective acquiring technological mastery is not simply to produce in the present: it is equally to be able to adapt technology and to anticipate changes in world and domestic markets. Thus, it is also necessary to develop the capacity to innovate in various respects. It is unclear how far this capacity can be developed solely on the basic of production engineering or project execution experience" (p. 133). The evidence from dependence studies strongly argues that the answer to their query is negative.

fall in a static trap, apparently led by their theoretical paradigm. In fact, the anti-Schumpeterian approach which characterizes the IIL view of technological development seems to lead them to disregard the cyclical nature of international economic development and to overlook the "primary" technological changes which are under way and which will deeply affect the international division of labor.

The rather optimistic picture the IIL studies drew of the future international division of labor rests upon at least two important *ceteris paribus* clauses. First, that investment and world trade will continue to grow, possibly at even higher rates than they did in the post-war period, in order to create more niches to accommodate not only the present LDCs which export technology, but also the others which follow on their path. Second, that there is no major technical change which will erode the comparative advantage given by the technological development of LDCs.

Now, the two conditions outlined above are sharply contradicted by recent events. International trade and investment have plunged, as the world economy has got into a crisis which finds a parallel only with the thirties depression. In such cyclical downswing, the NICs which followed an "outward-looking" development strategy have emerged as prime casualties as the "miracles" became horror stories. A Schumpeterian approach to development strategies could lead to the inclusion of consideration of a "cycle-elasticity of patterns of development" in recommendations of policies to LDCs. Thus, it may well be that a more inward-looking strategy, although it has the cost of profiting less of the expansionary phase of the cycle, may have the benefit of suffering less during the downswing. In this context of speculation, perhaps it would be useful to look again at the old thesis of Prebisch (1949) (formulated for the evolution of terms of trade) that, **in the present international division of labor, the LDCs stand to lose more in the downswing of the cycle than they gain in the upswing**.

Although the way out of the present cycle is not in sight, it is clear that it will be associated with a deep change in the technical basis of the world economy, of which some aspects are already visible in the development of electronics and biotechnology.

Those two new technologies are, as is well known, based upon "large-scale scientific activity on the frontiers of technology" and their activities are to a considerable extent (aimed at meeting changing needs of high-income, brand-conscious consumers, i.e. they are exactly the opposite activities in which, according to the IIL school, the LDCs have comparative advantages. The resources used for innovation in these industries are highly concentrated in the advanced countries and the theory and experience of diffusion of innovations strongly suggest that the rate of diffusion of such innovations will be much faster in the centre than in the periphery, widening their gap; not only in research and development (R&D) but also in manufacturing technology.

Moreover, the diffusion of electronics will affect many of the activities in which the NICs could have comparative advantages as regards both more and LDCs than them. This applies, for instance for the simpler (non-electronic) machine-tools and the labor-intensive detailed design services they would sell to the advanced countries [Lall (1982a)], which are likely to be replaced by numerically-controlled machine tools and computer-aided design,[15] produced more efficiently in the central countries. The latter may also prove to be strong competitors in the markets of the LDCs (markets not to be overlooked in the present crisis), since electronics will reduce the costs of adaptation of designs and of scaling-down of processes and equipment to suit the specific need of such countries.[16]

[15] For evidence on the gap of diffusion of electronic-based capital goods between central and peripheral economies, see, among others, UNCTAD (1982) and Tauile (1983). For computer-aided design, see Kaplinsky (1982). The latter's conclusion on the role played by electronics in widening the gap between DCs and LDCs is the same as ours.

[16] As it is well known, one of the main features of the electronic innovations is that they break the link between automation and large-scale production, allowing for the automation of batch production.

Another cycle-related factor which may reduce the technology exports of LDCs is their capacity to finance them. Although the IIL studies tend to overlook the role played by finance, to concentrate on technology, it is well known that in such markets the former plays a role at least as important as the latter. The present balance of payment problems faced by countries such as Brazil, Mexico, Argentina and Korea will probably undermine further their technology export capability by reducing their capacity to finance such exports in conditions similar to those provided by the more advanced countries.

Finally, the present phase of the cycle may lead to **reduction** of the technological capability of the LDCs, not only in relative terms (the widening gap argument outlined above), but also in absolute terms, by two mechanisms. The first is the closure of local firms, unable to resist the international crisis and the restrictive policies local governments have put in practice to control inflation and balance the external account (at least in Latin America). The sectors producing the goods and services composing the technology exports are likely to be especially affected, given the role of the demand from local public enterprises for their survival. The drastic cut-down in public investment in such countries finds no compensation from increased exports, since protectionist and/or contractions policies are spreading, with feedback effects.[17] In fact, Cruz, one of Katz collaborators, has repeatedly warned that, the closured of such enterprises means the liquidation of a technical capability which will take long to reconstruct, even when the new upswing comes [Cruz (1982)].

The second mechanism is the shift of manufacturing from LDCs to the central countries by multinational companies. Stimulated by the new

[17] For instance, one of the leading manufacturers of machine tools in Brazil recently went into receivership when their Mexican market closed. The reduction of investment of OPEC countries will also reduce the markets for the LDCs technology exports.

possibilities of automation opened up by electronics and by an increased weight attached to product-quality in competition, this seems to be already happening in electronics semiconductor production [Rada (1982)]. Kaplinsky's contribution to this volume explores this phenomenon in some more detail, suggesting that the new technologies abode bad for the manufacturing technology capability of the LDC.

Thus, the present phase of the cycle does not seem to support the optimism and the policy implications of the IIL authors. By way of finalizing, we can point to another similarity between them and dependence authors: if the latter suffered from not assessing properly the opportunities opened up by the boom phase of the cycle, the former did not seem to have fully appreciated the implications of the present decline phase. All in all, old Schumpeter (and Marx) may still have a lot to teach all of us.

A FINAL NOTE

Economists seem to hold a peculiar relationship to technology. Having recently discovered they had neglected the theme since the days of Schumpeter, the profession now seems to display symptoms of serious guilt-inspired behavior – on the one hand, it proclaims the overriding importance of technology, on the other, they beat the breast about their ignorance on the subject. Such ritual is rendered easier by disregarding the work done outside one's own parochy.

The two bodies of literature discussed in this article argue against the behavior described above. They show that over the past decade and a half we have accumulated a substantial body of knowledge about an important phenomenon in the process of technological development in LDCs and how it relates to the technological development in DCs. Moreover, we have also advanced our knowledge about the relationship between technological

development and other features of the development of the LDCs (e.g. industrial structure, role of foreign capital, the roles played by the State and so on).

The preceding sections also argue against technological "naïve optimism." No matter how important technology is – and we have argued it is important –, it cannot by itself change the pattern of development of LDCs or the international division of labor. Not there are grounds to believe that technological development necessarily leads to general progress and greater equality. Contrary to the Victorian hopes we still entertain, technological development may be associated to "perverse" patterns of development – one more reason to study it and try to orient it.

However, we should also avoid the pitfalls of narcissism. Our areas of ignorance in this field (as in so many more of development) are vast, as shown, for example, by the difficulty of explaining the phenomenon of non-learning. Therefore the tradition of pleading for further research deserves to be honored once more. To finalize, this article enters a further plea – for more communication between researchers working on similar subjects. It doesn't cost much and it may help a lot.

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