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# National Learning Systems

## A new approach on technical change in late industrializing economies and evidences from the cases of Brazil and South Korea

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**Abstract:** This paper has two intertwined parts – a proposal for a conceptual and theoretical framework to understand technical change in late industrializing economies and an empirical test of the usefulness of that new framework by means of a comparative study of the Brazilian and South Korean cases. The first part asserts that the unwarranted use of the *National Innovation System's* (NIS's) approach to late industrializing economies could incur in serious shortcomings. The comparative analysis of Brazil and of South Korea, developed in the second part of the paper, demonstrates that the system of technical change of each country can be characterized as cases of, respectively, *Passive* and *Active National Learning Systems*.

**Keywords:** development, industrialization, innovation, learning, technical change, technology, passive learning, active learning, technological capabilities, national innovation systems, national learning systems, industrializing economies, Brazil and South Korea.

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# 1. Technical Change in Late Industrializing Economies – Building Conceptual and Theoretical Blocks\*

## 1.1. National Innovation Systems and Industrializing Economies

Technical change is a crucial factor to economic growth and development. A framework for the analysis of technical change at the level of national economies - National Innovation Systems (NIS)<sup>1</sup>, introduced recently, has had a strong appeal to those interested in understanding the connections between technical change, growth and development of late industrializing economies. There are, at least, three main reasons for such an appeal: technical change is at the core of NIS's analysis; this approach aims at explaining the reasons for long lasting differences in the performances of national economies; and institutions and history are taken seriously into consideration. No other analytical framework presents these general features, which are so promising for the understanding of economic development.

In spite of such high hopes, the existing NIS's studies of late industrializing economies seem to have accomplished very little.<sup>2</sup> The main reason for the poor performance of this specific use of such a framework of analysis does not rest entirely on the lack of good data basis on those countries. A basic reason for that lies in the NIS's theoretical approach itself. The NIS theoretical and conceptual framework is not appropriate for dealing with the processes of technical change typical of industrializing economies, which are extremely different from those of industrialized countries.

The large majority of NIS's studies are focused primarily on scientific and technical activities aimed at innovation, especially, with R&D. Nelson (1993, p. 518), for instance, acknowledges that this was the case in the 15 nations' studies he coordinated, which involved industrialized as well as industrializing economies. That narrow understanding of NIS<sup>3</sup> is notionally opposed to the broad definition of NIS, which, in its rather few studies, encompasses institutions (and relationships) that influence, directly and indirectly, the innovation process.<sup>4</sup>

The narrow understanding of NIS is particularly inappropriate for the study of industrializing economies. This is so because the process of technical change characteristic of these economies is largely shaped outside the realm of those institutions that are at the core of the *innovation (stricto sensu)* process. The use of the broad

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<sup>1</sup> See on NIS, e.g., Freeman (1988, 1995 and 1999), Nelson (1993), Lundvall (1988 and 1992) and Edquist (1997).

<sup>2</sup> Kim's (1993) study of South Korea could be singled out as just an exception that proves the rule.

<sup>3</sup> Nelson's (1988) analysis of the US system is a classical example of the narrow approach to NIS.

<sup>4</sup> Freeman's (1988) analysis of the Japanese system is a good example of a broad approach to NIS.

understanding of NIS could still be of little help in dealing with industrializing economies if the analysis remains based on the kind of notion of *innovation* that is, in practice, subjacent to the majority of NIS's studies. The use of a concept of *innovation* almost as a synonym to technical change is frequent. In this case, *innovation* is taken as a process that has linkages and feedbacks with and, as a matter of fact, connects all the elements of the Schumpeterian triad — *invention*, *innovation (stricto sensu)* and *diffusion*, together with the more recent concept of *incremental innovation*.<sup>5</sup> Such an encompassing concept could be seen, at first sight, as opening up the door for the analysis of elements of technical change that are at the center of the process of technical change of industrializing economies, as it is the case, for instance, of *diffusion*. However, by undifferentiating those elements, the current use of *innovation* as almost synonymous of technical change ends up by hindering any productive use of the broad NIS approach for the study of industrializing economies.

Even those NIS's studies, which are explicitly committed to the broad approach and do not use a lax concept of *innovation*, usually relegate to a lesser position those elements of technical change other than *innovation (stricto sensu)*. The concept of *innovation (stricto sensu)*, knowingly or unknowingly, ends up by assuming a central role in those studies. When, for instance, aspects related more specifically to *diffusion* are included, the analysis of those aspects is generally concentrated in their roles in fostering or hindering the process of *innovation (stricto sensu)*, and not in the role of diffusion in its own capacity.

The usual practice of placing R&D institutions, resources and outputs at the center of any type of NIS analysis is an indicator of its usual concern with *innovation (stricto sensu)*. The frequent use of R&D statistics as a proxy for a wider range of S&T activities is acknowledged to be unsatisfactory (Winter, 1987; Bell, 1991; and Freeman, 1992). Freeman, for instance, (1994, p. 473) states in this respect that “*In some industries and in the industrial countries R&D measures are reasonably good surrogate for this wider range of activities but in others they are not.*” Freeman's realization that R&D statistics were not good proxies of S&T activities in non-industrial economies were corroborated by one of the main findings of a research coming from a different theoretical background: an exercise of cross-country growth analysis (Gittleman and Wolff, 1995). That study concluded (ibid., p. 189) that “*R&D activity is significant in explaining cross-national differences in growth only among the more developed countries. Among middle income and less developed ones, the effects are insignificant.*” We suggest that R&D statistics should be good surrogates for technological activities in general only in those industries or countries in which *innovation (stricto sensu)* is the leading form of technical change.<sup>6</sup>

Therefore, the bias of NIS studies towards *innovation (stricto sensu)* does not seem to

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<sup>5</sup> The observed difficulties to determine, in the cases of some specific technologies, where each one of these elements ends, and where the other begins, are thought to be a good justification for not making a clear-cut analytical distinction between them, and, therefore, a good reason to mix them up in a loose concept of innovation.

<sup>6</sup> The notion of “leading form of technical change” is used here in the sense of most influential, the pacesetter of technological competition, and not necessarily in the sense of the most frequent or the one that has the most important direct impact on productivity.

have harmful consequences as long as the systems of *innovations* under scrutiny are of advanced industrial countries, i.e., countries where *innovation (stricto sensu)* is at the core of the process of technical change. However, this is not the case for late industrializing or developing economies, i.e., countries in which *innovation (stricto sensu)* has a secondary role, possibly, no role at all, in the process of technical change.<sup>7</sup>

The simple extension of the use of the National Innovation Systems' approach to the analysis of late industrializing economies is then unwarranted. It likely impairs the very understanding of the nature, pace and direction of the process of technical change of those economies, and, therefore, the identification of their determinants, as well as, it could induce inappropriate policy prescriptions.

The conceptual and theoretical problems indicated above are the main reasons why the high hopes set upon the NIS' approach as a tool for understanding the connections between technical change, growth and the development of late industrializing economies became unfulfilled.

However, the general framework of analysis introduced by the NIS' approach could still be some how useful for that purpose as long as it could be detached from those problems.

A preliminary step would be required before moving forward in that direction: to realize the differences there are between what Schumpeter has called *development* in the beginning of the twentieth century and what *development* means nowadays. For Schumpeter, *development* is understood as the process of economic transformation brought about by *innovation*. His concept of *development* could, therefore, be seen, to a certain extension, as a background for the whole conception of the National Innovation Systems' approach. This is so because such an approach is just a tool for the study of a country's ability to generate *innovations*, which would stand, in Schumpeter sense, for a country's ability to "*develop*".

However, Schumpeter's notion of *development*, as it was formulated in the "*Theory of Economic Development*", was much more related to the idea of the capitalist development in general, than to the idea of the *development* of national economies, in particular. If there was any idea of national economies implicit in his formulations, it was an idea of development associated specifically with the leading capitalist economies, i.e., with those national economies that were leading the process of capitalist development by means of their strong *innovation* process.

The NIS' approach has contributed by adding up a specific national dimension to the Schumpeterian tradition, but it still remain focused on phenomena characteristic of the leading capitalist economies.

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<sup>7</sup> Cooper (1992) presents an interesting discussion on the relevance of *innovation* studies of industrialized economies to technology policy in developing countries. He thinks that this relevance is, at least partially, jeopardized by the fact that "*there is comparatively little technological innovation taking place there, especially if innovation is strictly defined to mean the first commercial introduction of a product or process in the international economy*" (Cooper 1992, p. 11).

Dealing with the question of *development*, defined as a departure from underdevelopment (a notion established approximately forty years later than Schumpeter's "*Theory of Economic Development*"), would require a step further.

## 1.2. National Learning Systems

The industrialization process is what accounts for the emergence of the cleavage between developed and underdeveloped countries. Those countries that were not among the pioneer processes of industrialization need to struggle to industrialize in their search for development. Industrialization after the Second Industrial Revolution, however, is a significantly different process. At the core of the specificities of late industrialization there is a particular technical change process.

*Innovation* is the engine of capitalist development as a whole. Nevertheless, processes of technical change led by *innovations* are usually a privilege of industrialized countries. The processes of technical change of industrializing economies are usually limited to the absorption and improvement of *innovations* produced in the industrialized countries.

However, the fundamental distinction between the processes of technical change of industrialized and industrializing economies is usually hindered by the current tendency towards an increasing conceptual imprecision in the literature on technical change, as already indicated. One of the reasons that are usually utilized as excuse for such an imprecision is the growing awareness of the interactive relationships that there exist between *invention*, *innovation (stricto sensu)*, *incremental innovation* and *diffusion*. The awareness of such interdependence, however, does not justify an indiscriminate use of these concepts.<sup>8</sup>

In spite of their rich interaction, each one of those forms of technical change presents enough differences to justify their independent existence in our conceptual framework. Such an understanding is strengthened when one realizes the great differences there exist in the processes by which they are created, the diverse capabilities they require, and the varied meanings they have for the competitiveness of firms, industries and nations. The preservation of the identity of each one of those concepts is, in general, required. It is particularly crucial, though, for building a specific framework for the analysis of technical change in late industrializing countries.

The need to maintain the independent existence of each one of those concepts, however, does not get in the way of recognizing the strong association there exist specially between *diffusion* and *incremental innovation*. This recognition led us to propose the use of an

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<sup>8</sup> If the distinction between *innovation* and *diffusion*, for instance, is misleading, as suggested, for example, by Bell and Pavitt (1993, p. 259), why should both concepts be preserved? If it is not possible to distinguish one concept from the other, there would be two methodological solutions for this *imbroglio*: either only one of the concepts is used, or a third concept replaces both of them. However, as there is an actual need for the preservation of each of them, a third, although inadequate, solution has prevailed: the use of both concepts without a clear distinction between them.

additional concept that encompasses (but does not replace) both of them — the concept of *learning*.<sup>9</sup>

*Learning*, we propose, is the process of technical change achieved by *diffusion* (in the perspective of technology absorption) and *incremental innovation*. In other words, *learning* is the absorption of already existing techniques, i.e., the absorption of *innovations* produced elsewhere, and the generation of improvements in the vicinity of acquired techniques.

Having settled these basic conceptual definitions, it is possible to go ahead in our effort to understand the process of technical change characteristic of late industrializing countries.

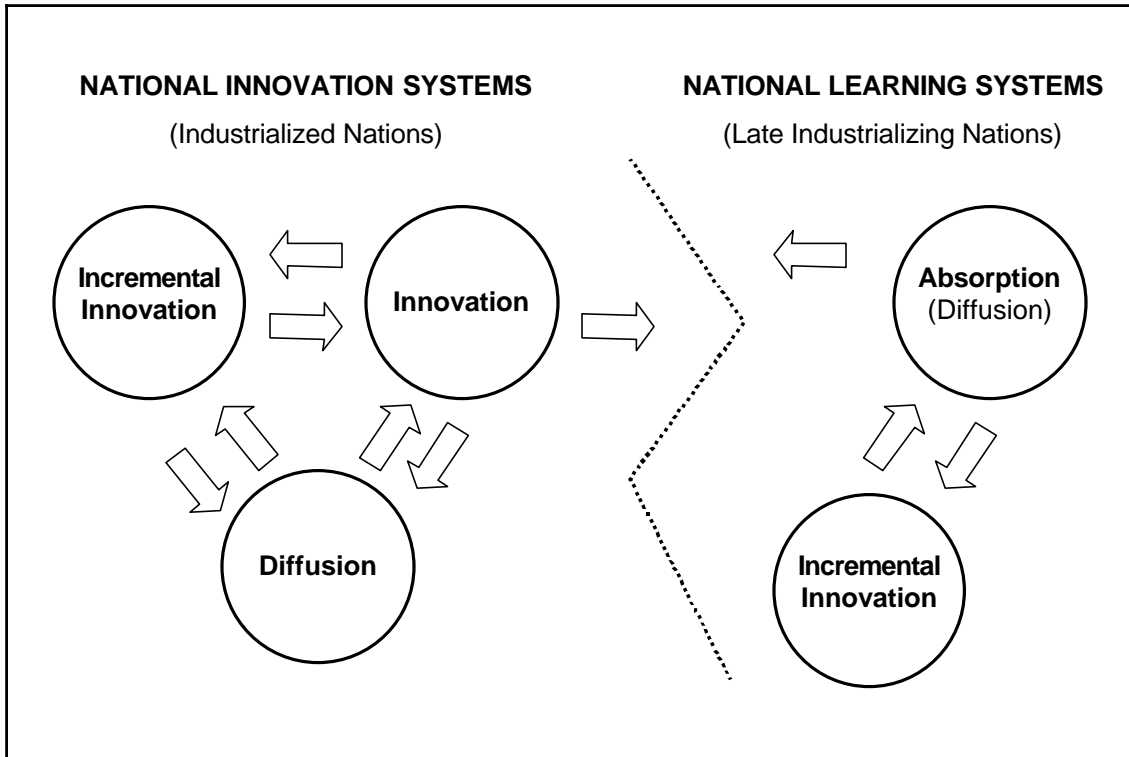
The dynamic engine of late industrialization is, then, technological *learning*, rather than *innovation*.<sup>10</sup> Therefore, *National Systems of Technical Change* of late industrializing economies have a crucial common element, which is their condition of technological learners. This is the reason why we propose that the use of the concept of *National Innovation Systems* should be ascribed exclusively to the analysis of cases of advanced industrial countries. For the analysis of the *National Systems of Technical Change* of latecomers, we propose, then, the use of the concept of *National Learning System* — NLS — with all its methodological implications.<sup>11</sup> Figure 1 presents a simplified vision of the elements of technical change that compose the two basic types of *National Systems of Technical Change*.

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<sup>9</sup> The concept of *learning* is also plagued with imprecision. Arrow (1962) pioneered a theoretical tradition by introducing the concept of *learning-by-doing*, basically associated with an understanding of technical change as a continuous process of acquisition of experience in the production activity. A myriad of other concepts of learning, each one of them referring to a specific form of acquisition of technical skill and knowledge, was added to Arrow's initial concept of learning. Nowadays there is also a recent tendency towards a kind of broad understanding of *learning*, in which technical change, in general, is interpreted as a kind of learning process. We think, however, that *innovation (stricto sensu)* could not be seen as the result of a simple process of learning, it should rather be associated with the ordinary understanding of something like creation, rather than learning. The process of generating *incremental innovation* and absorbing *innovation*, however, certainly involves several mechanisms of learning.

<sup>10</sup> The concept of *innovation* will be, henceforth, used in Schumpeter's original meaning, instead of *innovation (stricto sensu)*, used so far in order to differentiate it from the usual encompassing understanding of the concept. In other words, *innovation* will, from now on, in this paper, stands for the type of technical change achieved by the production of (the first commercial transaction involving) a new product, process, system or organization. Moreover, it should be stressed the fact that the originality involved in this definition could never be defined just in terms of a firm, region or country. The introduction, even for the first time, of a technique generated elsewhere in a firm, region or country is just *absorption (or diffusion)*, and not *innovation* in the Schumpeterian sense.

<sup>11</sup> Chapter 2 of Viotti (1997, pp. 33-105) develops a much thorough analysis on the specificities of technical change in late industrializing economies, the proposed National Learning Systems' approach, and its methodological implications.



**Figure 1 – National Systems of Technical Change**

The most important implication of such a differentiation is, obviously, the fact that the analysis of *National Learning Systems* should be centered in the activities, institutions, and relationships, associated to *learning*, rather than to *innovation*. *Absorption*<sup>12</sup> and *incremental innovation* should, therefore, be the main focuses of studies of NLSs.

### **1.3. Basic Technological Capabilities of Industrial Firms**

An excursion analyzing firms' technological capabilities is instrumental for acquiring a better understanding of National Learning Systems, i.e., to advance a step further in our effort of building conceptual and theoretical blocks for the analysis of technical change in late industrializing economies.

The development of countries depends on their firm's ability to create income, increase productivity, compete and grow. Contrary to the beliefs of conventional economists, and according to the understanding of ordinary people, businessmen, Marxists and neo-Schumpeterians alike, firms differ from one another, and one of the most important differences of them are their ability to acquire, assimilate, use, adapt, change and create

<sup>12</sup> *Absorption* is just the process of *diffusion* perceived from the perspective of the recipient of the technique. Contrary to neoclassical understanding, *diffusion* is not just a matter of contagion. A technique is diffused only when it is effectively assimilated, and this depends on the ability and on the efforts developed by the recipient firm, industry or country. Hence, *diffusion*, from the perspective of the absorber, is something different from *diffusion*, from the perspective of the diffuser.

technologies. The concept of different *technological capabilities*<sup>13</sup> attempts to capture that notion of differences in firms' abilities to carry on technical changes. That concept is very useful for the understanding of the nature, direction and pace of the process of technical change that happens not only in firms, but also, in industries, regions or countries.

Although a great variety of specific *technological capabilities*<sup>14</sup> can be identified, we propose to organize them in three basic categories:<sup>15</sup>

- The *production capability* – the knowledge, skills and other conditions required for the process of production;
- The *improvement capability* – the knowledge, skills and other conditions required for the continuous and incremental upgrading of product design, performance features and of process technology; and,
- The *innovation capability* – the knowledge, skills and other conditions required for the creation of new technologies, i.e., major changes in the design and core features of products and production processes.<sup>16</sup>

In order to give a much more concrete notion about the meaning of those categories, we elaborated Table 1, which presents some technical functions performed by industrial firms that are understood as typical of each one of the three basic technological capabilities. There is no need to scrutinize each one of the technical functions and the reasons by which they are related to a particular technological capability, they are relatively obvious.

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<sup>13</sup> The concept of *technological capability* was developed in a number of different ways by several authors of the Indigenous Incremental Learning Literature – IILL, as Erber (1983) has called it. See on that concept, for instance, Bell (1984), Dahlman, Ross-Larson and Westphal (1987), Westphal et al. (1990), Enos (1991), and Lall (1987, 1990, and 1992a, b, c).

<sup>14</sup> OECD (1992, p. 262) stresses the fact that the notion of *technological capability*: “goes well beyond engineering and technical know-how to include knowledge of organizational structures and procedures as much as knowledge of behavioural patterns, e.g. of workers and customers. Firms need certain complementary assets and capabilities in order to create, mobilize and improve their technological capabilities, among which may be noted organizational flexibility, finance, quality of human resources, sophistication of the support services and of the information management and coordination capabilities.”

<sup>15</sup> The IILL's authors used to stress the particular type of technological capability required for the establishment of new, and the expansion or modernization of old industrial plants. This capability was not considered to constitute one of the basic ones.

<sup>16</sup> These characterizations of each technological capability draw heavily on OECD (1992, p. 262), in spite of the facts that they were christened here, and a fourth capability adopted by OECD, related to project investment, was deemed not relevant to this stage of the work, as pointed before.



**Table 1**  
**BASIC TECHNOLOGICAL CAPABILITIES AND TYPICAL TECHNICAL FUNCTIONS**  
**OF INDUSTRIAL FIRMS**

<b>TYPICAL TECHNICAL FUNCTIONS</b>	
<p><b>PRODUCTION CAPABILITY</b>            (Knowledge, skills and other conditions required for the process of production)</p>	<p style="text-align: center;"><b>Assimilation of process/product technology</b>  <b>Passive incremental innovations</b></p> <ul style="list-style-type: none"> <li>• Minor adaptation to local conditions (of infrastructure, goods and services supply, human resources, and product demand)</li> <li>• Balancing the process/line of production</li> <li>• Simple debugging and routine maintenance</li> <li>• Inventory control</li> <li>• Management of inputs procurement and output sales</li> <li>• Quality control of final products</li> <li>• Sporadic training</li> </ul>
<p><b>IMPROVEMENT CAPABILITY</b>            (Knowledge, skills and other conditions required for the continuous and incremental upgrading of product design and performance features and of process technology)</p>	<p style="text-align: center;"><b>Mastering of process/product technology</b>  <b>Active incremental innovation</b></p> <ul style="list-style-type: none"> <li>• Major adaptation to local conditions (of infrastructure, goods and services supply, human resources, and product demand)</li> <li>• Shop-floor experimentation</li> <li>• Preventive maintenance</li> <li>• Networking with suppliers and consumers</li> <li>• Total quality type of control systems</li> <li>• Permanent training</li> <li>• Product/process improvement</li> <li>• Equipment stretching and adaptation</li> <li>• Regular search for outside knowledge and skills, including benchmarking, copying, imitation and reverse engineering</li> <li>• Science and technology links</li> <li>• In-house R&amp;D</li> </ul>
<p><b>INNOVATION CAPABILITY</b>            (Knowledge, skills and other conditions required for the creation of new technologies, i.e., major changes in the design and core features of products and production processes)</p>	<p style="text-align: center;"><b>Innovation of product/process technology</b></p> <ul style="list-style-type: none"> <li>• Process/product innovation</li> <li>• In-house R&amp;D</li> <li>• Basic research</li> <li>• Cooperative R&amp;D</li> <li>• Licensing own technology to others</li> </ul>

**Note:** Except for cases of innovation startups, the technical functions typical of the technological capability of *innovation* usually subsume those of *improvement*, as well as, these last ones comprise those of *production*.

What require much closer attention are the two different concepts of *incremental innovation* utilized in Table 1. The importance to differentiate *incremental innovation* from *innovation*, itself, was already pointed out. However, even when a clear definition of *incremental innovation* is utilized, there remains room for some conceptual misunderstandings. This is so because it is possible to identify *incremental innovations* that are generated by two different processes of learning.

There is a type of *incremental innovation* that is a consequence of a process of learning-by-doing. This process is called by Bell (1984, p. 190) as “doing-based learning”, and he indicated (ibid., p. 189) that it has three remarkable properties: it arises passively, little or no explicit action is required to capture it; it is virtually automatic; and it is practically costless, a kind of free by-product from carrying on with production. The outcomes of “doing-based-learning” should be called, we propose, *passive incremental innovations*, and these are clearly associated with just the *production capability*.

There is, however, another type of *incremental innovation* that arises from a completely different process of learning, the one that is a consequence of deliberate efforts and investments in technology. Bell (1984, p. 190) called this process as “non-doing-based learning”. We propose to call the outcome of “non-doing-based-learning” as *active incremental innovation*, and this is a kind of hallmark of the *improvement capability*.

Another dimension should, at this point, be added to our framework of analysis. There are some forms of technology *absorption* that are prone to generate more opportunities for *active incremental innovations* than others. Forms of technological absorption that follow the pathway of minimal technological effort (the “black-box” approach), like, for instance, turnkey projects, license agreements and foreign direct investment, generate mainly opportunities for *passive incremental innovations*. We characterize those forms of *absorption* as *passive absorption*.

This type of *absorption*, which targets the assimilation of almost only just the abilities needed for the establishment of the capacity to produce certain goods or services, generates opportunities of learning that hardly go beyond the simple development of *technological capabilities of production*.

Forms of technological absorption that require a more intense technological effort, as, for instance, imitation and reverse engineering, are likely to produce not only a deeper mastering of the absorbed technologies, but also a richer array of opportunities for *active incremental innovation*. We characterize those forms of technological absorption as *active absorption*. This type of *absorption* generates opportunities of learning that usually go far beyond *production capability*, it is one of the bases for the development of the *technological capability for improvement*. Table 2 presents some examples of *passive* and *active* forms of technology *absorption*.

**Table 2**  
**EXAMPLES OF PASSIVE AND ACTIVE FORMS OF TECHNOLOGY ABSORPTION**

FORMS OF TECHNOLOGY ABSORPTION	
<b>PASSIVE ABSORPTION</b>	<ul style="list-style-type: none"> <li>• Investment projects by means of turnkey contracts or direct foreign investment</li> <li>• Technology licensing</li> <li>• Purchasing of equipment packages linked with technical assistance from the capital goods supplier</li> </ul>
<b>ACTIVE ABSORPTION</b>	<ul style="list-style-type: none"> <li>• Investment projects progressively under firm's control</li> <li>• Technology and equipment procurement progressively under firm's control</li> <li>• Imitation</li> <li>• Reverse engineering</li> <li>• Copying</li> </ul>

Some evidences have shown, however, that a particular form of technological absorption could have different meanings when it is fitted in a firms' long-term technological strategy. An apparently *passive form of absorption* could occasionally be accompanied by a deliberate effort for mastering the technology being absorbed. In other words, some times a *passive form of absorption* could just represent an initial and deliberate step towards *active learning*. This seems to be the case, for instance, of some large Korean conglomerates that deliberately utilized OEM (Original Equipment Manufacturing) agreements as just an initial step in an aggressive and active pathway towards technological learning, as described in Amsden (1989).

After this relatively large process of building theoretical and conceptual blocks for analyzing technical change in late industrializing economies, Table 3 tries to present a kind of summing up of the relationships there are between each one of the basic technological capabilities, the corresponding elements of technical change, and technological strategies.

**Table 3**  
**TECHNOLOGICAL CAPABILITIES AND STRATEGIES**

TECHNOLOGICAL CAPABILITIES	ELEMENTS OF TECHNICAL CHANGE					TECHNOLOGICAL STRATEGIES
	Absorption		Incremental Innovation		Innovation	
	Passive	Active	Passive	Active		
<b>Production</b>	X	—	X	—	—	<b>Passive Learning</b>
<b>Improvement</b>	X	X	X	X	—	<b>Active Learning</b>
<b>Innovation</b>	X	X	X	X	X	<b>Innovation</b>

**Note:** The symbol "X" (" ") denotes the existence (lack) of the corresponding element of technical change.

#### 1.4. From Firms' Technological Capabilities to Passive and Active National Learning Systems

The empirical evidences based on the few available case studies on technical change at firm level in industrializing economies<sup>17</sup> give some important clues about the typical technological capabilities of those firms. First of all, not even one firm among those, which were studied, presented effective *innovation capability*, in the sense defined before. Several case studies identified the existence of very poor processes of learning, a technical change process limited to the simple assimilation of *production capability*. One of these is an influential study by Bell et al. (1982) about an industrial plant for the production of galvanized steel sheets in Thailand, which was considered by the authors to be an example of failure in terms of technological accumulation.<sup>18</sup>

There are reasons to believe that the simple assimilation of *production capability* is the most typical case of firms' technological strategy in developing economies. We characterize this kind of process of technical change as a *passive learning strategy*. In other words, the *passive learning strategy is the one in which the technological effort developed is essentially aimed at the absorption of production capability.*

Other studies have, however, revealed the existence of advanced processes of *learning* in which firms go much beyond the simple absorption of *production capability*.<sup>19</sup> The technological effort associated with it reflects a commitment also to develop the *improvement capability*. We characterize as *active learning strategy* the technological strategy that aims at the mastery of *production capability* together with the *improvement capability*.

It should be recalled that each one of those studies emphasized the fact that these cases of successful *learning*, i.e., of *active learning*, were the result of a conscious commitment to technological accumulation. Referring to some of those case studies, Bell (1984, p. 206), for instance, concluded, in this respect, that “*case-studies like those of Sabato (1973), Sercovitch (1980), Enos (1982), and Dahlman and Fonseca (1978) (...) emphasize the role of deliberate, aggressive investment in the*

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<sup>17</sup> The most important studies were the result of a large program of study of Latin American firms coordinated by Katz. See, for instance, Dahlman (1978), Maxwell (1977), and Katz and Albin (1979). The main achievements of that program were condensed in Katz (1987). For an Indian case study see Lall (1987). For surveys of such studies see, for example, Dahlman and Westphal (1982), Bell et al. (1982), and Dahlman, Ross-Larsen and Westphal (1987).

<sup>18</sup> The authors of the study (Bell et al., 1982, p. 150) concluded their analysis of that firm in the following way: “*One simple conclusion emerges from this analysis. Over a period of at least about nine years this infant industrial firm did not improve any of four important aspects of the production efficiency of three lines which produced its basic standard product. Nor did operating efficiency improve following the introduction of the two new vintages of capital equipment. In terms of production efficiency, the firm seems to have remained technologically stagnant during this period. There were no technically fixed limits which prevented minor modifications and improvements of these lines.*”

<sup>19</sup> Beyond the case studies by the IILL literature, Amsden's (1989) classical study of South Korea gives several examples of firms (*Chaebols*) with amazingly intense processes of such a kind of advanced *learning*.

*accumulation of technology-capital — investment that is made in the context of coherent, long-term strategies, and in the light of “hard-nosed,” but social rather than private, perspectives on the returns to that investment.”*

Cooper (1992, p. 15) also arrived at the similar conclusion that (what we call in this paper) *active learning* could not be seen as a natural and common behavior of firms from late industrializing countries:

*... in the absence of appropriate external institutional conditions learning process may ... fail ... (...) The failure of learning processes in developing countries is in fact quite common. It is reflected in what is often called a “black-box” approach to production technology encountered quite often in developing country firms which receive technology via license agreements: firms may be unconcerned about how the technology works, provided only that they are able to produce with it. There are also reasons to expect that firms in developing countries may underinvest in learning processes.*

Those conclusions show not only the notion that the identified cases of *active learning* were the result of deliberate and aggressive commitment to technological learning, but also that overcoming the limitations of *passive learning* by firms depends on external conditions.

In principle, any individual firm is free to choose its technological strategy, being it *passive* or *active learning*, or even *innovation*. Therefore, on an individual basis it would be perfectly possible, in a certain sense, to think of firms' technological strategy as just a matter of choice. However, the particular strategy that prevails in a country<sup>20</sup> is a completely different phenomenon. It depends on the nature of the National System of Technical Change in which firms are embedded.

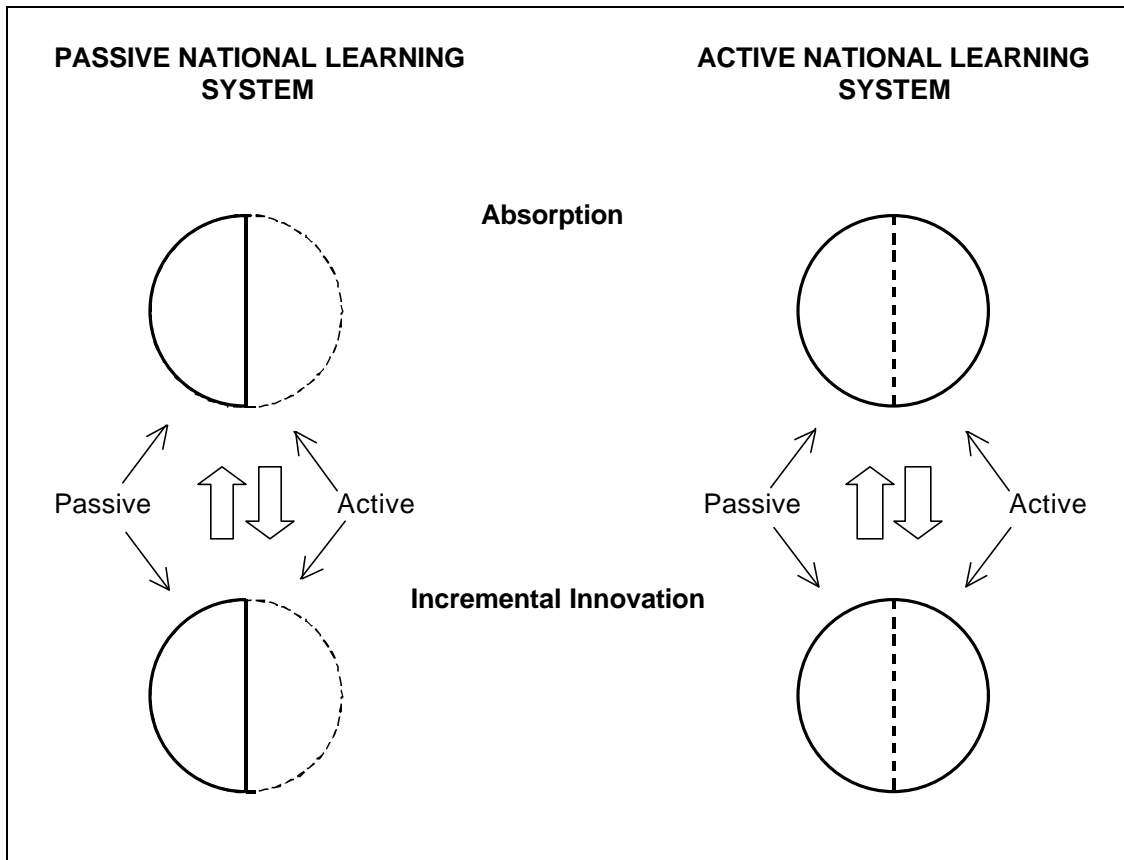
Moreover, those accounts of cases of successful learning firms seem to favor the understanding that the natural strategy that prevails in late industrializing economies is generally the *passive* one. Overcoming the *passive strategy* seems to be possible only where there are the “*appropriate external institutional conditions*”, which allows for “*deliberate, aggressive investment in the accumulation of technology-capital*” with some kind of “*social rather than private, perspectives on the returns to that investment.*” In other words, there are some suggestive clues indicating that the simple functioning of the market incentive mechanisms are prone to favor just the *passive learning strategy* in late industrializing economies. To foster the prevalence of the *active learning strategy* in these economies seems to be a task for a more complex set of institutions, relationships

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<sup>20</sup> The question of aggregation involved in the determination of what type of firms' strategy dominates in a national economy is not a minor question. Pavitt's (1984) identification of sectoral patterns of technical change should be taken as a strong indication that there are also structural reasons for the simultaneous coexistence of different technological strategies amongst manufacturing sectors. Obviously, there should happen to exist different firms' strategies living together in any national economy at any moment in time. Unfortunately, then, the question of which technology strategy prevails could not be reduced to the mere identification of the strategy that is followed by the larger number of firms. The solution for such a question should be searched for in the behavior of the leading firms (i.e., those which set the pace of competition and that, usually, are also the best practice firms) of all sectors, and mainly in sectors other than the *supplier-dominated* ones.

and incentives.

Summing up, it is possible to understand the three different natures of National Systems of Technical Change from the perspective of firms' technological strategies. Those economies in which the processes of technical change are dominated by firms' *innovation strategy* should be characterized as *National Innovation Systems*, whereas economies dominated by *active* or *passive learning strategies* should be characterized, respectively, as *Active* and *Passive National Learning Systems*.



**Figure 2 – National Learning Systems**

Figure 2 presents a simple representation of *National Learning Systems* of *active* and *passive* nature by means of showing the different types of *absorption* and *incremental innovation* that characterize them. *Passive National Learning Systems* are basically limited to the type of *incremental innovation* that is a kind of free by-product from carrying on with production (i.e., *passive incremental innovation*), and the type of technological *absorption* that follow the pathway of minimal technological effort (i.e., *passive absorption*). *Active National Learning Systems* add up to the forms of technical change typical of *passive learning*, indicated above, those forms of *incremental innovation* that are consequence of a deliberate technological effort (i.e. *active incremental innovation*), as well as the forms of *absorption* that require a more intense

technological effort (i.e., *active absorption*).

Concluding this brief excursion through the analysis of some scattered micro evidences of the technological behaviors typical of late industrializing economies, two considerations on further research must be stressed. First, the growing importance of the national systems' analytical approach should not inhibit further research on firms' case studies. As a matter of fact, the promotion of further studies of this kind is crucial for the advancement of the effective understanding of the technical change process of those economies. Second, firms' case studies are not substitute for the direct inquiry on the general features of the technical change process at the national level, and also the analysis of the institutions and relationships that shape such a process.

The second part of this paper develops an analysis of macro evidences of the most successful industrializing economies of Latin America — Brazil — and of East Asia — South Korea. There are reasons to believe that the greatly different recent performances of these two economies are rooted in two significantly different processes of technical change. Those differences do not seem to constitute simply national nuances among processes of technical change typical of late industrializing economies, i.e., they do not seem to be just differences between National Learning Systems. They seem to reveal National Learning Systems of different natures. The comparative analysis of the two economies will investigate the hypothesis of the existence of actual cases of National Learning Systems of a *passive* and an *active* nature.

## **2. The Natures of the National Learning Systems of Brazil and South Korea**

Some basic macro-indicators will be used to support the assumption that Korea was successful in its transition towards an *active learning system*, whereas Brazil was not. Those indicators can be organized under four different categories: the national patterns of education and training of the labor force; national patterns of technology acquisition; national patterns of commitment of resources to technological learning; and indicators on the outcome of the national technological effort.

### **2.1 The National Patterns of Labor Force Education and Training**

Indicators of the national patterns of labor force education and training are presented in Table 4. Korean, like developed countries, has overcome, in practical terms, adult illiteracy. Brazil, however, still shows a rate of adult illiteracy at 16.7 per cent in 1995, which means that a sixth part of the Brazilian potential labor force is not prepared to make a meaningful contribution to technological *learning*. Korea made an extraordinary effort to improve secondary education during the last decades and achieved near universality in 1993 for their population in the age group between 12 and 17 years old. That same year, less than half of Brazilians in the corresponding age group were enrolled in secondary school. Furthermore, the quality of the Brazilian secondary education ranked very poorly, amongst the worst ranked countries in the world, whereas the Korean was among the best, as it was inferred by a 1991 international standardized tests in science and mathematics (IAEP/ETS 1991, and NSB 1996).

**Table 4**

**NATIONAL LEARNING SYSTEMS – BRAZIL AND SOUTH KOREA**  
**Selected Indicators on**  
**LABOR FORCE EDUCATION AND TRAINING**

<b>Indicator</b>	<b>Brazil</b>	<b>South Korea</b>
Adult illiteracy (1995)	16.7	2.0
Percentage of age group in secondary education (1993)	43	93
Performance of secondary students in 1991 international standardized tests in science and mathematics	Amongst the world's worst scores	The world's best scores
Percentage of age group in tertiary education (1993)	11.5	48.2
Number of tertiary students per 100.000 inhabitants (1992)	1,079	4,253
Percentage of first university degrees in engineering (1992)	7	18
Tertiary students abroad (as % of those at home) (1985-92)	0.1	2.7
Percentage of the population at working age enrolled in vocational training	(1985) 1.83	(1986) 3.06

**Source:** Viotti, Eduardo, *Passive and Active National Learning Systems*, 1997 (Tables 2; 3; 4, and pp. 184-185; 187-188; 186, and 192-193).

**Note:** Number between parentheses corresponds to the year of the data.

The Korean effort in improving third level education is striking. Approximately half of the corresponding age group was enrolled in tertiary education in 1993, a ratio of enrollment that is even slightly better than that of the average developed country. Approximately a ninth of the corresponding age group of Brazilians were enrolled in tertiary education in 1993. The number of tertiary students per 100 thousand inhabitants in Brazil (1.079) is approximately a fourth of that of Korea (4.253). Moreover, the proportionally small number of tertiary students in Brazil seems to be inadequately distributed by fields. Brazil has a low proportion of university or college bachelors in the fields that are most important to the needs of a late industrializing economy. Engineers play a crucial role in the process of absorption of foreign technology, making it operational, and improving it. *Active learning* requires a relatively large pool of well-educated and trained engineers. Brazil, however, had a very low percentage of its total first university degrees in engineering in 1992, only 7 percent, whereas such a percentage in Korea was 18 percent.

The patterns of national labor force education and training depicted by the analyzed indicators shown that Korea was able to rapidly and effectively develop a well educated and trained labor force, fulfilling, thus, such a requirement for a successful transition towards an active NLS. Brazil, on the other hand, in spite of important improvements in the last decades, remained with a relatively poorly educated and trained labor force, which hindered its prospect for a successful transition for an active NLS.



A well educated labor-force in general, and, in particular, a large pool of qualified engineers, are a necessary, but not sufficient, condition for overcoming a *passive learning* strategy. Their effective and efficient engagement in a national technological effort is also essential. From a different perspective, “human capital” would not become an effective technological absorber or improver (not even a factor of production) without its effective engagement in productive or in science and technological activities. Though education is a necessary condition for the effective acquisition and improvement of technologies, it is not a sufficient one. Good education does not ensure, for instance, direct access to technologies of production. The inquiry will, then, be directed, first, to assessing the national patterns of technology acquisition, second, to the national patterns of commitment of resources to technological *learning*.

## 2.2. The National Patterns of Technological Acquisition

A good idea about the nature of the process of technological absorption could be given by how late industrializing economies acquire technology. These economies have three major sources of formal acquisition of technology: technology embodied in capital goods imported from advanced industrial countries — CGI; technology brought about by foreign direct investments — FDI; and the direct purchase of technology by means of foreign technology licensing and technical assistance — DPT.

Statistics about those different ways of acquiring technology are scarce, difficult to assemble, and could be affected by differences in national legal regulations. In spite of these difficulties, the sparse and not entirely compatible data gathered in Table 5 could give some idea about the Brazilian and Korean patterns of technology acquisition.

Assuming that the values of the flows of foreign direct investment, capital goods imports, and direct purchase of technology keep a certain correlation with their technological contents, the data presented in Table 5, together with some other information presented in Viotti (1997, Tables 6, 7, 8, 9, 10 and 11), give an indication of the relative importance of each one of these flows for each country. The overall picture could be summed up in three basic stylized facts about technology acquisition in Brazil and Korea:

- The most important source of foreign technology in Korea was, and continues to be, imports of capital goods, while such a source plays a relatively secondary role in Brazil;<sup>21</sup>
- Foreign Direct Investment plays a major role in the Brazilian acquisition of foreign technology, and a minor role in Korea;
- Foreign licensing and technical consultancy was of relatively small importance for both Korea and Brazil; however, its importance is increasing at a very fast pace for Korea.

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<sup>21</sup> Note that Korean imports of capital goods as a ratio of its gross domestic investment shown in Table 5 is larger than one. This is explained by the fact that Korea re-exports an important share of the imported capital goods as components of exported goods. This is the case, for instance, of naval engines.

Table 5

**NATIONAL LEARNING SYSTEMS – BRAZIL AND SOUTH KOREA**  
**Selected Indicators on**  
**TECHNOLOGY ACQUISITION**

<b>Indicator</b>	<b>Brazil</b>	<b>South Korea</b>
Imports of capital goods as a ratio of the GDI (1987)	0.259	1.066
Foreign direct investment up to 1986	US\$ 27.4 billion	US\$ 3.6 billion
Direct purchase of technology	(1984-1988) US\$ 827.8 million	(1982-1986) US\$ 1,517 million
Imports of US industrial processes (1993)	US\$ 7 million	US\$ 287 million (Second only to Japan)
Imports of Japanese technology (1993)	– <sup>a</sup>	¥ 53 billion (Second only to US)

**Source:** Viotti, Eduardo, *Passive and Active National Learning Systems*, 1997 (Tables 6, 7, 8; 9; 10, 11, and p. 215).

**Notes:** GDI stands for Gross Domestic Investment. Numbers between parentheses indicate the years to which the data corresponds. (a) Brazilian imports of technology from Japan in 1993 were not remarkable enough to be shown in the table of Japanese exports of technology.

The great importance imports of capital goods play in the Korean process of technical change suggests that the acquisition of innovations generated in advanced industrial countries, which are imported embodied in new vintages of capital goods, is playing a fundamental role in keeping Korea in a dynamic track of technological *absorption*. This feature seems to have been very fortunate for the Korean system in the period of the information and communication technological revolution. The very rapid transformation of the technological frontier in the world seems to have impaired the functioning of the fertile interaction mechanisms that a larger domestic basis of capital goods industry should, otherwise, have given Brazil.

With respect to the other formal source of foreign technology, foreign direct investment, Brazil seems to be a champion. Brazil received US\$ 27.4 billion of foreign direct investment until 1986, whereas Korea received only US\$ 3.6 billion. Dahlman and Frischtak (1993, p. 433) estimate that Brazil had the largest stock of foreign capital among developing country. The Korean Exchange Bank estimated that Korea's stock of DFI in 1983 was only 7 per cent of that of Brazil (Kim, 1993, p. 360). There are assessments that in earlier periods, in 1963, "*the MNCs were entirely absent from the local [Korean] scene*" (Lim, 1982, p. 139, quoted from Evans, 1987, p. 207).

According to Viotti's (1997, Tables 6 and 8, and Graphs 8 and 9) estimates, FDI represented in Korea (up to 1986) less than 3 percent of the total value flow of the three "conventional" sources of foreign technologies, whereas it represented 44 percent in Brazil (in the period between 1987 and 1992). The relatively minimum role DFI plays in the process of technical change in Korea is further illustrated by the fact that foreign

investors in Korea usually participate as minority shareholders in Korean and foreign joint ventures, contrary to what happens in Brazil (Evans 1987, p. 208).

This fact reflects “... *Korea’s explicit policy of promoting its “independence” from multinationals in management control*” (Kim, 1993, p. 360), a policy which transformed foreign investment within the country in not only a matter of private decision, but also a matter of adequacy to the Korean industrial policy, as government approval for each foreign investment was required (Kim and Dahlman, 1992, p. 451). The recent process of progressive economic liberalization in Korea seems to have not yet changed significantly the secondary role of FDI as a source of foreign technology, nor the secondary role of multinational corporations in the Korean industrial arena.

The singular importance of FDI in Brazil is also a consequence of an explicit industrial policy. Dahlman and Frischtak (1993, p. 417), for instance, indicate that “*One of the key elements of the industrial development strategy [of Brazil] was to induce foreign firms to set up manufacturing facilities in Brazil. This consisted not only of protecting the local market but also of offering significant subsidies and special treatment for foreign investors.*”<sup>22</sup>

With the exception of few segments where foreign capital was not welcomed in Brazil (exceptions that have almost entirely vanished with the new constitution of 1988 and the subsequent reforms), foreign firms are present in almost all industrial segments in Brazil. Moreover, at least one of the most important transnational corporations is present in Brazil in virtually each one of all the most dynamic industrial segments (defining dynamism, here, in both commercial and technological terms) (Bielschowsky and Stumpo, 1996, p. 174). Foreign subsidiaries were estimated to be responsible for 33 percent of the whole industrial sales in the Brazilian domestic market, and for 44 percent of industrial exports, during 1990 (Bielschowsky and Stumpo, 1996, p. 174). Such a share of the domestic market for manufactures is no match to any other industrializing economy in the world, with the possible exception of Singapore (ibid., p. 174). By contrast, Kim and Dahlman’s (1992, p. 443) appraisal was that direct foreign investment “*had a minimal effect on Korean economy.*”

In conclusion, there is not the slightest doubt about the existence of very different national patterns of reliance on direct foreign investment as a source of technology supply in Brazil and Korea, and these patterns are mainly a consequence of their specific industrial policies. Conventional wisdom usually thinks of multinational corporations as a privileged agent of technological transference to late industrializing economies. However, it seems that FDI usually ensures just the *absorption of production capabilities*, i.e., FDI generally does not contribute for the development of an *active learning strategy*.

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<sup>22</sup> Dahlman and Frischtak (1993, p. 417) also indicate that as early as 1960 “... *foreign subsidiaries accounted for more than 50% of the capital goods producers, 70% of chemicals (except petrochemicals), 90% of pharmaceuticals, and 100% of the nascent automobile industry.*”

With the usual exception of adaptations for the domestic conditions, local branches of multinational corporations typically rely on their headquarters for providing for their needs of technology. The introduction in a late industrializing economy of a new industrial plant by a multinational corporation (MNC) frequently contributes to the modernization of the country's productive apparatus. However, this usually does good just for the upgrading of the country's *technological capability of production*. It usually does not necessarily do any good for the country's *capability of improvement or innovation*. It may well be that it does some harm because of the easy way the local branches of MNCs have to respond to local competitive pressures and opportunities by means of upgrading their *production capability* with the help of their headquarters. That reliance on a kind of "just-in-time" supply of production technologies, not only, renders unnecessary the technological effort of the local branch to build *improvement or innovation capabilities*, but could also inhibit the same type of effort by the local competitors due to the unfair competition it represents.

This dismaying role of FDI for the technological development of late industrializing economies could be one of the reasons for the very different performances Brazil and Korea present in this field. The macro-evidences of commitment of resources to technological learning, as well as, the outcome of the national technological efforts of Brazil and Korea (which will be analyzed in the next sections of this paper) seem to corroborate this interpretation. In other words, the Brazilian pattern of deep reliance on FDI seems to be related to the predominance of a *passive learning* strategy in Brazil, whereas the Korean pattern of very small reliance on FDI seems to be related to the predominance of an *active learning* strategy in that economy.

The third stylized fact about formal acquisition of technology refers to the direct purchase of technology. In both countries, the least important source of technology among the three "conventional" ones was the direct purchase of technology — DPT. Up to 1986, DPT represented in Korea just one sixtieth (1/60) of the total value flow of the three "conventional" sources of technology (Viotti 1997, Table 6 and Graph 8), whereas in Brazil it represented (between 1987 and 1992) less than one thirtieth (1/30) (ibid., Tables 7, 8, 9 and Graph 9). Therefore, the role of formal contracts of technology transfer was remarkably unimportant in comparison to all the three "conventional" sources in both countries until some years ago. One of the reasons for such a small relevance of direct purchase of technology in those countries was their industrial policies. Inspired by the findings of the Technological Dependence Literature, both countries have established strict controls on the direct purchase of technologies. Such a feature of their industrial policies was designed to improve the bargaining position of national firms, to curb restrictive business clauses tied to technology transfer contracts, and, especially in the Brazilian case, to minimize foreign exchange outflow (see Dahlman and Frischtak, 1993, pp. 429-432, and Kim, 1993, p. 360).

The way each country compensated for such a minimum reliance on direct purchase of disembodied technology was, however, very dissimilar. The first important difference was the relatively strong reliance of Korea on capital goods imports and of Brazil on direct foreign investment, already addressed. However, the second, and possibly much

more important, was the different role played in each country by forms of technology absorption other than those three “conventional” ones.

Those other forms of technology absorption could assume a wide variety, such as imitation; copying; reverse engineering; hiring skilled personnel; learning from machinery suppliers and independent consultants; overseas training of engineers, managers and also of skilled workers for apprenticeship at the factory floor. Because these forms are necessarily associated to a deep technological effort, it usually contributes to a superior mastery of process or product technologies, and, therefore, creates a basis for further improvements. These other forms of technology acquisition, which we called *active absorption* in the previous section, are hardly quantifiable and comparable. The literature on Brazil and Korea, however, presents scattered, but consistent evidences that the reliance on *active absorption* was much more important in Korea than in Brazil.

Capital goods imports, direct foreign investment, and direct purchase of technology ensures just the development of the technological *capabilities of production* — the only technological capability a passive learner usually develops. It should be noted, however, that overcoming the limitations of *passive learning* is not just a matter of reliance on “unconventional” forms of technology acquisition. An *active learning* strategy is not just a matter of substitution of “unconventional” for “conventional” sources of technology acquisition; it is rather a matter of complementarity. In other words, the cleavage between passive versus *active learning* is not a matter of alternative reliance on technology imports versus domestic technology development. It is rather a matter of complementarity between technology imports (i.e., *passive* and *active absorption*) and domestic technological improvements (i.e., the effective development of *improvement capabilities*). Such a complementarity was a key element in the technological strategy of those countries that were catching up from a position behind the technological frontier, as it was the case of Germany in the nineteenth century and Japan in the twentieth century (Bell and Cassiolato, 1993, pp. 50-54).

In 1993, Korea rose to become the second buyer of technology in US and Japan, i.e., Korea purchased more technology in Japan and the US than any other industrialized or industrializing country in the world, but the two largest industrialized economies themselves. In 1993, whereas Korea had a 10 percent share of the U.S. exports of industrial processes, Brazil had a share 40 times smaller (0.25 %) in the market that is its largest supplier of technology (NSB 1996, pp. 6-2). Brazilian imports of technology from Japan were not remarkable enough to be shown in the table in which Korea appears as responding for 11.5 percent of Japanese exports of technology (AIST, 1996, p. 36). The recent very high Korean expenditures on imported technologies, combined with still higher expenditures on engineering and R&D, seem to indicate that this country is imitating the Japanese postwar pattern of catching up. In contrast, the relatively very small Brazilian expenditures on technology imports were not compensated by a stronger reliance on domestic technological effort, as it will be shown ahead.

### 2.3. The National Patterns of Commitment of Resources to Technological Learning

The focus of analysis now turns to the third kind of macro-evidences on the national systems of Korea and Brazil: their national patterns of commitment of resources to technological learning.<sup>23</sup> The actual and meaningful commitment of resources to the technological effort is a necessary condition for mastering acquired technologies, and, at the same time, for developing capabilities to improve them, in other words, it is a necessary condition for *active learning*. The national commitment of resources to technological *learning* could be inferred from the national expenditure in R&D, the proportions of these resources that are expended at productive enterprises, as well as the size of the public financing for industry's R&D. The relative number of scientists and engineers effectively engaged in R&D activities, and the relative proportion of those directly working for the private sector, are other vital indicators. Table 6 presents these indicators of Brazilian and Korean commitment of resources to technological learning.

**Table 6**

**NATIONAL LEARNING SYSTEMS – BRAZIL AND SOUTH KOREA**  
**Selected Indicators on**  
**COMMITMENT OF RESOURCES TO THE TECHNOLOGICAL EFFORT**

<b>Indicator</b>	<b>Brazil</b>	<b>South Korea</b>
<b>Expenditure for R&amp;D as percentage of GNP</b>	0.4 (1994)	2.1 (1992)
<b>Expenditure in R&amp;D by source of funds (%)</b>	(1994)	(1992)
Government	81.9	17.2
Productive enterprise	18.1	82.4
Other	...	0.4
<b>Government preferential financing for industry's R&amp;D</b>	US\$ 810 million (1973-1989)	US\$ 848 million (1987)
<b>Scientists and engineers engaged in R&amp;D</b> (per million inhabitants)	235 (1993)	1,990 (1992)
<b>Researchers according to place of activity (%)</b>	(1986)	(1987)
Government Institutions	26.16	17.40
Universities	68.51	33.15
Private sector	5.33	49.46

**Source:** Viotti, Eduardo, *Passive and Active National Learning Systems*, 1997 (Tables 13; 14; and p. 226).

**Note:** Numbers between parentheses indicate the years to which the data corresponds.

Korean and Brazilian expenditures on R&D present very different patterns. In the beginnings of the 1990's the Brazilian share of its GNP devoted to R&D was just 0.4%, whereas Korea expenditure was more than 5 times larger, 2.1%. As a matter of fact, by the year 1991, Korea was leading all developing countries in R&D expenditures, as a

<sup>23</sup> This approach is related with what Soete (1981) called the "technology-input" type of measures of technological activities, in opposition to the "technology-output" type, which will be addressed in the following section of this paper.

percentage of GNP, and also surpassed OECD countries like Spain, Italy, Austria, Denmark or Finland (Lall, 1992c, p. 143).

The analysis of the composition of R&D expenditures is also of great importance. Similar quantitative expenditures on R&D could involve different qualities of expenditures. This understanding is helpful, not only to grasp differences between industrializing and industrial countries, but, also, to grasp differences among different stages of late industrialization. Kim (1993) and Kim and Dahlman (1992) stress the fact that Korean technological development has changed significantly in the 1980's, and they point the progressive relevance of research (R) in the composition of its R&D as one of the important changes.

Brazil seems to remain, during the 1980's and beyond, in a stage in which R&D, and especially R, remains largely irrelevant to its industrialization. There are strong evidences that a large part of its yet relatively small technological effort is irrelevant to the needs of Brazilian industry, because it is largely divorced from productive activities. As Table 6 indicates, government supported the large majority (81.9%) of R&D outlays in 1994, and the productive enterprises were directly responsible for a small part of the total R&D expenditure (18.1%). By contrast, the situation in Korea was symmetrically divergent. Productive enterprises were responsible for 82.4 per cent of the total expenditure on R&D, in 1992; approximately the same proportion the Brazilian government is accounted for in 1994 (81.9%). Therefore, the technological effort of the Korean industry, as it could be inferred from expenditures on R&D as a percentage of GNP, is approximately 25 times that of the Brazilian industry.

The relevance of such an effort of Korean industry is one of the reasons for the competitive edge attained by national Korean enterprises. At the same time, the Korean reliance on mainly national enterprises is one of the reasons for such a high level of domestic technological effort. However, such a performance was not only a consequence of market incentives and firm strategy, but also a result of Korean industrial policy. The Korean government has played a major role in stimulating industry's investment on R&D through direct R&D subsidy, tax incentives, and, mainly, preferential financing (Kim, 1993, p. 372). Kim (1993, p. 373) estimates that the total amount of public financing, mostly in the form of preferential loans, accounted for 64% of total R&D expenditure in manufacturing in 1987.

There was not a similar policy for stimulating industry's investment in R&D in Brazil. The only Brazilian institution devoted to financing industrial R&D — FINEP (*“Financiadora de Estudos e Projetos S. A.”*) — had a relatively small quantitative importance in fostering it. Dahlman and Frischtak (1993, p. 434) estimate that FINEP's financing operations during 17 years (from 1973 to 1989) represented an accumulated amount of only approximately US\$ 810 million. By contrast, Kim (1993, p. 373) indicates that Korean preferential financing for industry's R&D amounted to a similar value (US\$ 848 million) just in one year (1987).

The contrasting picture of Brazilian and Korean technological efforts inferred from the

size of their R&D expenditures, as well as from their industry's engagement in R&D, comes out also from their respective commitment of human resources to R&D. The number of scientists and engineers engaged in R&D per million inhabitants in Korea during 1992 (1,990 researchers) is more than eight times higher than that of Brazil in 1993 (235 researchers). Approximately half of the total of Korean researchers were working for the private sector (in 1987), whereas only 5.33% per cent of Brazilian researchers were found to be working in the private sector.

All those evidences on the size and composition of the two countries' commitment of resources to the technological effort lead to the conclusion that there are strong evidences of the predominance of a *passive technological learning* strategy, i.e., of a *Passive National Learning System*, in Brazil, and of an *Active National Learning System* in Korea.

#### **2.4. The Outcomes of the National Technological Efforts**

The evidences gathered about the outcomes of the national technological efforts of both countries (seen in Table 7) could reinforce such a conclusion. Only 14% of the (2,479) patents granted by the Brazilian patent office, in 1991, were granted to residents in Brazil, whereas, 69% of the (3,741) patents granted, during the same year, by the Korean patent office were granted to residents in Korea. The difference between the patent performances of both countries in the US is even greater. During thirty years (1963-93) Brazilian residents were responsible for less than one tenth of a percentage point (0.09%) of all the U.S. patents granted to non-residents, and such a share remained relatively stable all over that period. Korean residents' share of U.S. patents of foreign origin, during the same period, was, in average (0.31%) approximately three and a half times higher than that of Brazilians. Furthermore, Koreans' share showed a strong increasing trend. In 1993 Koreans seized a share (1,73%) more than thirteen times higher than the Brazilians (0.13%).

A huge share of the patents that have effective commercial application is, in general, comprised of *incremental innovations*. As it was shown, there are two types of *incremental innovations*, the *passive* and the *active* ones. There are reasons to believe that patents should be much more related to this last type of *incremental innovation* than to the former. Furthermore, as the first type of *incremental innovation* is understood to be basically the consequence of production experience, and as there is no special reason to believe that the Korean production experience is significantly larger than that of Brazil, Korean better patent performance should be ascribed mainly to its larger production of *active incremental innovations*. Therefore, Brazilians' very poor patenting activity at home, as well as in the US, is an additional evidence of the predominance of *passive learning* in its NLS, while the relatively very good patenting performance of Koreans is an additional indicator of the active nature of its NLS.

**Table 7**

**NATIONAL LEARNING SYSTEMS – BRAZIL AND SOUTH KOREA**  
**Selected Indicators on**  
**OUTCOMES OF THE NATIONAL TECHNOLOGICAL EFFORTS**



Indicator	Brazil	South Korea
<b>National Patents</b>		
National patents granted by the national bureau (1991)	2,479	3,741
Patents granted by the national bureau to residents (1991) (%)	14	69
<b>US Patents</b>		
US patents granted to residents in each country (1993)	57	779
Percentage of US patents granted to non-residents (1963-1993)	0.09	0.31
Percentage of US patents granted to non-residents (1993)	0.13	1.73
<b>Trade in high-tech products with the US</b>		
Exports of advanced technology products (1994) (US\$ million)	115.8	6,658.4
<b>Diffusion of new productive technologies</b>		
Robots per million in employment	52 (1987)	1060 (1987)
CAD <sup>a</sup> per million in employment	422 (1987)	1437 (1986)
NCMT <sup>b</sup> per million in employment	2298 (1987)	5176 (1985)

**Source:** Viotti, Eduardo, *Passive and Active National Learning Systems*, 1997 (Table 13; 15; 17, and 18).

**Notes:** (a) CAD stands for computer aid design workstations. (b) NCMT stands for numerically controlled machine tools. Numbers between parentheses indicate the years to which the data corresponds.

A similar conclusion could be achieved if one examines the relative size of the U.S. trade in advanced technology products with Brazil and Korea. The value of Korean exports of advanced technology products to the U.S. in 1994 (US\$ 6,658.40 million) was 57 times higher than that of Brazil (US\$ 115.8 million). Korean recent performance in advanced technology products is outstanding not only in comparison with Brazil. Korean exports of advanced technology products to the U.S., in 1994, were greater than those of, for instance, the United Kingdom, France and Germany, and lower only than those of Japan, Singapore, Canada and Malaysia (NSB, 1996, p. 254).

Specialization on advanced technology products, especially those related to electronics, has two very important meanings. The first one refers to the fact that those are “dynamic” commodities, i.e., commodities for which the growth of international demand is above average. Therefore, such a specialization provides a clear indication of a country’s capacity for sustaining the growth of its exports. The second meaning is directly related to the process of technical change, and its consequent productive growth and diversification. Trade specialization on electronic and telecommunication products comes with a relatively high level of mastery of *information* technology, and such a technology is at the core of the current technological revolution — the new *technological paradigm*, which is affecting every sector of the economy. Therefore, the mastery of *information* technology strengthens a country’s overall potential for technological development in general (i.e., for technological *learning* and *innovation*) and, hence, for competition in international markets.

Korean higher level of mastery of such a technology is, certainly, associated with its faster pace of diffusion of some of the most important modern technologies of production in manufacture – as robots, computer-aid-design (CAD), and numerically-controlled machine-tools (NCMT), as Table 7 shows.

It should be recalled at this point that the more modern the technologies are, the larger the opportunities for cumulative *incremental innovation* (and even for *innovation*). Therefore, the more modern the technology is, the more profitable its adoption could be for an *active learning strategy*.<sup>24</sup> Moreover, the information and communication technologies, for which there are evidences Korea is doing a relatively successful effort for mastering, are at the core of the new techno-economic paradigm and the periods of changing of paradigms are seen as historical moments that open up “windows of opportunities” for some learners to possibly become innovators (Perez, 1985; Perez and Soete, 1988). Therefore, Korea’s mastery of the technologies of the new paradigm could, in the long term, enable Korea to possibly benefit from that extraordinary and temporary historical condition that could allow some learning countries to become truly innovators.

Whether there are some evidences that Korea may be headed towards possibly overcoming the limits of its current situation of an Active National Learning System, Brazil still needs to develop a large effort to just surmount the narrow limits of its condition of a Passive National Learning System.

### 3. Conclusions

All the four types of macro-evidences of the technical change processes of Brazil and Korea corroborated, directly or indirectly, the hypothesis of the existence of actual cases of *National Learning Systems* of *passive* and *active* nature, as it was shown to be, respectively, the cases of Brazil and South Korea.

The contrast between the two processes of technical change proved remarkable, despite both processes being essentially and still confined to *learning*. The concepts of *passive* and *active National Learning Systems* showed how useful they were to apprehend the diversity of those realities, and, consequently, to avoid, for instance, interpretations which misleadingly suppose (based on conventional economic theory) that those countries have a similar lack of technological dynamism.<sup>25</sup>

An inquire on the reasons why the two most successful cases of industrialization in Latin America and in the South East constitute National Learning Systems of so different natures is not a specific object of this paper.<sup>26</sup> In spite of this, it should be advanced here

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<sup>24</sup> See Stiglitz (1987) on “*the greater learning potential associated with the newer technologies*” and its policy implications.

<sup>25</sup> Krugman (1994), trying to dismiss the importance of industrial policy for the East Asian growth performance, characterized it as just an “input driven” growth because “*the hypothesis that there has been no technical progress during the post-war period cannot be rejected for the four East Asian newly industrialized countries*” (ibid., p. 71). The same author attributed to the Brazilian fast growth of the 1970’s a similar “input driven” nature (Economist 1995).

<sup>26</sup> This issue is, to a certain extent, dealt with in Viotti (1997, Section IV of Chapter 4).

the fact that there are strong evidences (Wade 1990; Kim and Dahlman 1992; Amsden 1993; Amsden and Hikino 1993, and 1994; Kim 1993, and 1997; and Viotti 1997) that several aspects of the Korean trade and industrial policies were responsible, to a large extent, for building the right set of institutions and *stimuli* that induced industrial firms' technological dynamism. This indicates that policies are, to a great extent, responsible for the Korean ability to overcome the limits of *passive learning*, which is the initial and natural pattern of technical change of any late industrializing economies. That also suggests that the nature of the National System of Technical Change to which a country is attached is not just a matter of fate. It further suggests that the framework of analysis developed in this work could be also helpful for the evaluation and design of policies for late industrializing economies.

The use of the framework of analysis associated to the concept of *National Innovation Systems* for the evaluation and design of policies in a *passive learning* nation, as is the case of Brazil, for instance, would probably favor policies targeting essentially at *innovation*. Those policies will probably be impotent for developing an effective *innovating system* and, even, for fostering an *active learning system*. They will most likely deepen the observed divorce between the country's commitment of resources to its scientific and technological effort and the effective process of technical change of its productive firms.

If a late industrializing country does not wish to remain confined to a backward process of technological and economic development, its industrial and technological policies should relinquish the concept of industrial firms' as just technological "buyers". Firms should be seen (at least potentially) as major players in the process of technical change, even though industrial firms from late industrializing countries are not, in principle, innovators. The technological problem of those countries could not be reduced just to a question of increasing or improving the "supply" of technologies. Neither the technological problem of firms could be reduced just to the acquisition of technologies. Despite being confined to *learning*, firms should not be appeased with *passive learning*, they could and should strive to become *active learners*, and possibly creating the basis for eventually become *innovators*.

One of the endeavors of governments, enterprises and societies of late industrializing economies in their struggle to overcome their usual backward technological and economic development is to build the adequate institutions and create the type of environment that induces *active learning*, i.e., to create an *Active National Learning System*.

*Active learning* greatly stretches the limits of growth and of the development process of late industrializing economies, but it still is a limited process. The only virtually unlimited process of technical change, the only one that empowers a country to effectively achieve the status of developed nation (or even to forge ahead) is *innovation*. It is possible to say, then, that only "Schumpeterian development" is compatible with successful development, in the post-war sense. For late industrializing economies, however, *active learning* seems to be a necessary step towards *innovation*. As a matter of

fact, innovating firms do not necessarily go through an *active learning* phase; they could be born as innovating firms. However, a historical case of late industrializing economy born as *innovator* is not known. The only successful case of development of a late industrializing economy is Japan, and there are evidences that it went through a phase of *active learning*. Obviously, the transition from *active learning* to *innovation* is not certain, and it also depends on historical conditions and on the ability of nations to produce the institutional *innovations* required for the constitution of an actual *National Innovation System*.

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