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TECHNOLOGICAL CHANGE AND LATE INDUSTRIALIZATION : LESSONS FROM A POST KEYNESIAN EVOLUTIONARY APPROACH

Otaviano Canuto(*)

Abstract

The paper attempts to show how an evolutionary approach to technical change and the Post Keynesian concept of uncertainty can both provide theoretical microfoundations that allow a new approach to processes of technological learning in late industrializing economies. The first part contains a sketch of a general evolutionary framework to deal with relationships between competition among firms and technical change. In the second part, the theoretical framework is applied to international transfer of technology towards non-advanced economies, as well as to processes of local learning in those economies. The South Korean experience is taken as an illustrative object.

Resumo

O presente trabalho busca mostrar como a abordagem evolucionista aos processos de mudança técnica e a noção pós-keynesiana de incerteza fornecem microfundamentos teóricos que permitem um enfoque profícuo aos processos de aprendizado tecnológico em economias de industrialização tardia. A primeira parte contém um esboço de uma formulação geral sobre as relações entre os processos concorrenciais e de mudança técnica obtido da literatura "evolucionista", destacando-se a presença de conceitos pós-keynesianos. Na segunda parte, aplica-se o referencial teórico às transferências "externalizadas" e "internalizadas" de tecnologia para economias não-avançadas, bem como aos processos de aprendizado local nestas, tomando-se como ilustração a experiência sul-coreana.

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INTRODUCTION

This paper is an attempt to illustrate how the evolutionary approach to technical change and the Post Keynesian notion of uncertainty can both provide microfoundations that shed light on several aspects of technological learning in late industrializing economies. In our opinion, those aspects have not so far been satisfactorily treated in the literature on those economies.

The first part contains a brief outline of a general abstract framework about relationships between technical change and competition among firms which can be obtained from the "evolutionary" literature.[1] Special attention will be given to the role played within that framework by the Keynesian notion of uncertainty in firm-specific technological strategies (Section I.1), sector-specific features of technical change (Section I.2), and in technologically-related processes of competitive selection at the market level (Section I.3).

The second part deals with historical-concrete aspects of technological transfer and learning in late industrializing countries. After presenting some stylized features of processes of late industrialization (Section II.1), the paper sketches a framework to deal with foreign firms' decisions regarding "externalized" and "internalized" modes of technology transfer (Section II.2). Finally, the text approaches the South Korean "paradigmatic" experience of technological learning in late industrialization with the Post Keynesian evolutionary framework as the background (Section II.3).

1 See, e.g., the seminal works by Nelson & Winter (1977, 1982) and Dosi (1984, 1988) as well as the newly edited *Journal of Evolutionary Economics*.

I. TECHNICAL CHANGE AND COMPETITION: A BRIEF OUTLINE OF A POST KEYNESIAN EVOLUTIONARY APPROACH

I.1 Technological Dynamics as a Local-and-Specific Process at the Firm Level

In the conventional economic literature, technology is usually presented as generally applicable "information", that is to say, as knowledge about the transformation of inputs into outputs - in productive, managerial and trade spheres - which can be fully replicated and reused, independently of time and space. Technology is identified as a set of relationships between "factors of production" and output levels which serves as a unique and general reference to "choices of techniques" by all firms. Technological change is defined as a shift of that "menu" of techniques.

From an opposite point of view, several empirical works have stressed the presence of **tacit** and **specific (idyossincratic)** types of knowledge in any particular application of any technology (Nelson & Winter, 1977, 1982). By "tacitness" they mean some elements of knowledge that are both necessary for a minimally efficient use of each technology and embodied in the firm's routines and personnel. Consequently that "tacit" knowledge cannot be acquired or transferred by means of handbooks or any other codifiable forms of knowledge transmission. That knowledge cannot be made "explicit" as in blueprints and thus cannot be perfectly diffused as either public information or private property. By an "idyossincratic" or "specific" content they refer in turn to the fact that each materialization of generic and abstract principles of technology involves different conditions to become concrete - given the implausibility that contextual conditions be the same everywhere.

One can derive the following implications from those empirical observations:

Firstly, a fully complete transfer of technology is never attainable - either directly or indirectly between sectors or even intra-sectorally. Technology receivers inevitably get an information set not so complete as that one used by sources of transmission. Every technology transfer requires some development of tacit and specific technological capability by the receiver, however high or low be that content.

Secondly, technological dynamics is necessarily local and firm-specific. Whatever the weight of external sources in the firm's process and product innovations, the latter correspond to a process of interaction between technical innovations and technological capabilities accumulated at the firm level. Technology is both an input and an output of the exercise of technological capabilities, since technical and technological changes come up simultaneously at the firm level.

The **learning** process (i.e. the accumulation of technological capabilities regarding operation and innovation activities) at the firm level has both internal and external sources as possible starting points:

- internally, R&D investment as well as informal learning (which includes the operation learning which accompanies the exercise of activities, such as the one depicted in traditional "learning curves"); and

- externally, there are flows of information of a public character (such as the ones coming from scientific breakthroughs), flows of information available as merchandise (coming from the same or other sectors, either disembodied or embodied in equipments or components), non-tradable technological spillovers (such as the information exchange between users and producers), etc.

In any case, learning results from the cumulative process of interaction between external and internal sources at the firm level, process in which a tacit and idyosincratic knowledge is inextricably present.

Thirdly, technological research at the firm level carries on a highly selective heuristics (Nelson & Winter, 1982). Directions in innovative efforts are not established at random since they refer to local and specific problems.

A commonly forgotten feature of innovative efforts is the fact that they are essentially problem-solving activities, dealing with "ill-structured" problems (Dosi, 1988:1126): the set of available information by itself cannot provide perfectly clear-cut paths to solutions and the latter come along with some discovery and creation. It follows that there can be no perfect foresight about technical results of innovative activities, since there is no basis upon which to build a previous knowledge of all possibly resulting events, even less so as to attribute any probability distribution to them. One can thus find **(technological) expectations** and **uncertainty**, in an analogous manner as Keynes pointed out with respect to capacity-building investment, short-run pricing and production decisions, etc.

Since learning is a resource-consuming and costly process - the rhythm and intensity of which depend upon the firm's decisions regarding information collection, R&D, labor training and so forth -,[2] it constitutes a specific item in the firm's agenda for investment decisions. Investment in learning as such involves a double-sided dimension insofar as expectations and uncertainty are concerned: its return depends on both technological and economic results (Freeman, 1974; Nelson & Winter, 1977). Inasmuch as one can understand the adherence to "routines" as a possible rational attempt to safeguard against uncertainty - as developed e.g. by Davidson (1978) and Possas (1990) - one can also realize how technological uncertainty may be a stimulus for the firm to stick to its more familiar "practices", namely its selective heuristics and local-and-specific technological capabilities.

On the other hand, actual or desired changes in the firm's performance and/or in competitive environment inflict a continuous tension between the relative safety provided by routines and the search for new ones. To this respect, the appraisal of technological and economic signs is subject to not only firm-specific expectations formation under conditions of uncertainty, but also to different degrees of confidence on those expectations and to different propensities to take risks. Any given set of observable signs common to all firms involved is liable to generate behavior diversity, not only because each firm's capabilities and routines are local and specific, but also because signs are interpreted in an idyosincratic and possibly-changing way.

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2 Informal learning is usually taken as something which follows time authomatically. Nonetheless one must recall that that kind of learning depends upon quality of hired labor as well as on the levels of technological capabilities accumulated from the other sources which it interacts with.

I.2 Sector-specific Patterns of Technological Change

Selectivity in firms' heuristics regarding learning activities is tantamount to following a previous demarcation of relevant problems and of a pattern for research (i.e. of a limited set of technological possibilities and its expected developments). Whenever a minimum set of common features may be localized among ever local-and-specific learning processes and heuristics, one can stylize a "technological paradigm" - such as proposed by Dosi (1984,1988) in his analogy between science and technology evolutions.

A technological paradigm involves "a basic artifact to be developed and improved (such as a car, an integrated circuit, a lathe, each one with its own particular techno-economic characteristics)" as well as a corresponding "set of heuristics" (Dosi, 1988:1127). The "basic artifact" must of course be understood as a tangible or intangible output which becomes the object of one or more technically-related productive processes and in which common or at least coherent directions of technological investigation are settled, with respect to its production and/or product characteristics.

Paradigms have different reaches, not only in terms of sectors and markets gathered as stages of the productive chain, but also regarding the set of users which have their (also selective) heuristics influenced by the techno-economic features of the basic artifact.

Certainly in cases where scientific knowledge is relevant as an external source of learning, the former's abstract and ordered structure is also present in technological activity and evolution. On the other hand, it is worth recalling that the concreteness of the technological paradigm involves tacit-and-specific knowledge components, as well as lower degrees of articulation and codification, and strongly depends on capacities developed through experience. A paradigm lives through the technological diversity among firms in which the "basic artifact" is produced and used.

Technical progress generally corresponds to increasingly better answers to multiple technical and economic trade-offs established as the subject of innovative activities. For instance:

- the evolution of the "basic artifact" automobile proceeds upon its trade-offs concerning conflicting performance characteristics (comfort, fuel consumption, speed, etc.);

- an electronic component is improved within its trade-offs with respect to reliability, cost/performance ratios, etc.;

- alternative processes of steel production represent distinct options regarding physical input-output relations, energy consumption and/or environmental damage;

- a consulting service firm searches for better responses to its trade-offs between speed and quality of the output, etc.

In all those cases, technical change goes along as one or more "technological trajectories" defined by the paradigm - such as the "normal" development of scientific paradigms in Thomas Kuhn's analysis.

Each paradigm has some degree of "technological opportunity", that is to say a potential in terms of benefit and cost results stemming from innovative efforts according to methods and directions there established. That potential depends, among other things, on the limits which "physical laws" or "natural laws" impose to paradigmatic lines with respect to the trade-offs contained in its corresponding processes and products (Perez & Soete, 1988:41). On the other hand, the actual development along trajectory lines towards the exhaustion of that potential depends on its economic appraisal as an investment decision according to technological and economic expectations formed under conditions of uncertainty.

A "radical innovation" - i.e. the emergence of some new product or process with techno-economic performance features so different from existing ones as to signify a discontinuity in the productive system - opens up a new paradigm and the corresponding trade-offs with respect to the characteristics of its "artifact". Well-established trajectories of incremental innovations towards improvement/adaptation of processes and products tend to come up only after the new paradigm is settled.

That paradigm settlement will depend on its competition with existing paradigms, since it will appear with some (even if imperfect) substitutability with respect to the latter - except for those cases of extreme novelty. Selection among old and new paradigms will take place both on *ex ante* levels (when agents estimate subjectively the degrees of technological opportunities) and on the *ex post* level (through actual economic results coming from market processes).

Expectations of favorable technological opportunity are a necessary but not a sufficient condition for investment in accumulation of technological capabilities within a paradigm, since "appropriability" is required in order to allow innovations to become rent-generating assets. "Appropriability" conditions will vary from technology to technology, given specific properties of technological knowledge, artifacts, markets and legal environment which can make difficult competitors' imitation (Dosi,1988:1139). Appropriability will express itself through time lags and differential costs of imitation relative to innovation.

Given the partial tacitness of technological knowledge, imitation is also a "creative process": the local and firm-specific nature of technological dynamics requires (re)search for imitation. Innovation and imitation - innovation and diffusion among firms - are not perfectly distinguishable, except for the fact that they are different moments with respect to constitution and dissolution of competitive advantages, as well as to technological divergence and convergence among firms.

In short, technology-specific estimated degrees of opportunity and appropriability constitute firm-specific and sector-specific inducements to technological investments and change. Market signals exert their influence (upon intensity and directions of innovative efforts) within the boundaries of prevailing paradigms and trajectories as well as according to the way by which they enter firms' expectative calculations.

On the other hand, as far as the rhythm and directions are concerned, technological development also keeps a "relative autonomy" in its relation with science - so that it is misleading to treat technology simply as a parameter derived from scientific advancements. In spite of increasing links between science and technology, the latter involves tacit and specific forms of knowledge, dealing with a particular sub-set of activities, and it does not evolve as a mere shadow of the former since its concreteness requires a properly economic calculation. Scientific knowledge continually opens up a multiple scope of potential paradigms which can acquire existence only after enduring a selection through "bridging institutions" (Freeman, 1974) as well as at the firm (*ex ante*) and market (*ex post*) levels. Science, technology and markets keep relative autonomy in their connections.

I.3 Technical Change and Competitive Asymmetries

The firm-specific character of technological dynamics, the presence of technological and economic uncertainty in investment decisions associated with technological accumulation by learning, the selectivity in heuristics, as well as appropriability and cumulativeness[3] of technological capabilities, all point to a particular view on relations between technology and competition among firms:

(I) Selectivity in heuristics leads to the search for improvements along prevailing technical lines rather than movements along "isoquants", even if that heuristics takes into account - within the technical boundaries of prevailing trajectories - some bias coming from original stimulus or restraint to technical change. This is in sharp contrast with the conventional view on production and technical change, according to which flexibility of production processes and full knowledge and access to a unique set of production possibilities allow for reversible choices within a common "menu" for all firms.

(II) Given irreversibility of learning and its cumulative character the productive structure is best represented by fixed coefficients which move along time. At a particular slice of time there are one or more points corresponding to best-practice techniques, i.e. the technology frontier, rather than a well-behaved set of production possibilities. Through time, processes of

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3 The selective exercise of innovative activities along maintained directions results in accumulation of capacities within the latter. There is "cumulativeness" whenever the probability of achievement of technological advances increases with the stage of that accumulation. The formulation of opportunity, appropriability and cumulativeness as categories to deal with sector-specific patterns of creation/destruction of technological asymmetries among firms was originally provided by G. Dosi - e.g. Dosi (1984).

technical improvements in best-practice techniques predominate over "static" factor-substitution processes (Dosi, 1988:1145).

(III) Technological diversity among firms tends to originate technological asymmetries due to opportunity, appropriability and cumulativeness. The firm-specific nature of technological-and-technical change allows for monopolistic/oligopolistic advantages, whether short-lived or not: higher or lower sustainability is what makes them different. In other words, firms can be ordered in a ranking according to their positions relatively to sector-specific technological frontier. The asymmetries thus classified change along time and are often unstable, but are not necessarily unsustainable as it is proposed in the conventional neoclassical approach.

Following Dosi *et al* (1990:88), let us take an **n**-dimensional space defined by **n** inputs to represent the techno-productive structure of a homogeneous-product sector, where the physical output/input relation is measured by the distance from the origin. The technical evolution of each firm within its own pattern will correspond to a discrete set of period-specific points reasonably ordered around a ray coming from the origin, the direction of which represents the firm's trajectory. If all firms are crossing similar trajectories one would find - at each moment of time - each firm as a point in a period-specific set in which distances express degrees of asymmetry. The absolute and relative positions of firms will evolve as a result of technological opportunity and innovative/imitative search by each one.

The asymmetric configuration of productive efficiencies will also reflect, at each slice of time, static economies of scale in production which can be made possible by prevailing technologies - the appropriation of which will be related to market shares held by each firm. Furthermore, one can add non-technological asymmetries, such as preferential access to some inputs and/or market shares, as well as pecuniary economies of scale in advertising, marketing, distribution and so forth. In any case, the local and firm-specific accumulation of technological capabilities may play a crucial role in a dynamic evolution of levels and dispersion in productive efficiencies, whatever the degree to which the process is associated to equipment vintages, R&D activities or other sources of learning.

Degrees of asymmetry express themselves as a dispersion in monetary costs, with the latter reflecting differences in productive efficiency in the use of each input as weighted by each corresponding input price. Product differentiation in turn may be conceptually incorporated by converting differences in performance regarding product characteristics to a single dimension, by using some market-defined weight.[4] Innovational search by each firm is a strategic attempt to alter market structures in its favor by creating or diluting asymmetries.

(IV) Technological asymmetries (which are part of the market structures at each moment of time) and firms' strategic decisions (which are conditioned but not determined by the former) interact and make up an evolutionary trajectory, one which is *ex ante* indeterminate - or rather multideterminate -, since expectations and uncertainty in the choice of strategies preclude any unique determination of structure upon firms' conduct and performance. *Ex post* changes in market structures and firm performances will result from absolute and relative intensities of firm-level learning processes (the effective results from search) and from market-level selection.

4 One must not forget that within a paradigm and its trade-offs product differentiation corresponds to differences in performance with respect to a certain set of techno-economic characteristics which make the paradigm unique.

Technological investment by firms as an economic decision implies that it is intertwined with the other dimensions of investment decisions (such as finance and productive capacity). Furthermore, technological opportunity, appropriability and cumulativeness are all appraised and ultimately realized in a firm-specific idyosincratic way. Therefore, those three attributes of each technological paradigm/trajectory are compatible with multiple paths of structure-strategy interaction.

A final caveat: the fact that there is some indeterminacy in the chain of interaction between technological asymmetries and firm strategies at each market level makes room for historical-institutional aspects, as well as for government policies, in any interpretation of real processes. By the same token, region-specific features may participate in the passage from microfoundations to aggregate historical movements.

II. TECHNOLOGICAL CHANGE AND LATE INDUSTRIALIZATION

II.1 Technological and Financial Discontinuities in Late Industrialization[5]

By late industrialization we mean those processes through which some developing countries have - since the mid-1950s - managed to change their productive structures towards one in which heavy industries (metallurgy, chemicals and metal-working products) play a significant role in local economic dynamics. They seemed to be reproducing - in a faster and timely concentrated fashion - the original industrial path along which developed countries evolved since last century. Nonetheless, a closer look at late industrializing processes reveals two sets of specific features which are derived from the fact that they sprang up in a historical moment when original heavy industrialization had already fully taken place.

(A) Late industrialization corresponded to the entry in industrial sectors in which technological trajectories endowed with high opportunity and appropriability were close to exhaustion. The integration between electricity, mechanics and combustion engines had already yielded a wide generation of standardized durable consumer and capital goods as well as strongly-automated capital-and-scale intensive processes associated with the so-called "rigid automation".

5 The following points were developed by Canuto (1993).

On the one hand, late industrializing processes had to face highly developed technological asymmetries and productive-efficiency advantages abroad in most heavy sectors. Technological learning and scale requirements in some of those sectors were such as to make them hardly feasible in non-advanced economies. In any case, protection of local "infant heavy industry" - i.e. newly created technological production capabilities - was a precondition for its survival.

On the other hand, the search for standardization in products and processes in order to reap the possibilities of "rigid automation" had led to a minimum the tacit dimension in technological operation (production) capabilities within many heavy branches in advanced economies. Consequently, partial transfer of technology appropriated as intangible assets by firms from advanced countries - to inaugurate production capabilities abroad - had become increasingly possible, either via foreign direct investment (the "internalized" way) or as a merchandise ("externalized" ways such as licensing, turnkey-plant contracts, technological and minor-sharing participation in joint-ventures, etc.). Innovation capabilities were in turn too tacit to be even partially replicated.

"Maturing" of late industrialization thus became a question of local learning upon imported production technology sufficiently fast so as to reduce productive-efficiency gaps and to make subsidies from other sectors less necessary. In some branches, maturing would require some local development of innovation capabilities wherever process and/or product innovations were not completely exhausted: a "reverse learning" going from operation to innovation capabilities, in an opposite direction as compared to the original sector development.

(B) Late industrialization involved a large quantitative and qualitative discontinuity in local processes of capital accumulation. Not only because of each sector-specific increase in scales which accompanied automation-technology development, but also for strong "agglomeration economies" regarding a minimum core of heavy sectors. Those "agglomeration economies" were due to the presence of reciprocal requirements in terms of demand or input availability among heavy sectors that constituted large advantages in favor of their simultaneous implantation. Late industrialization corresponded to a "revolution" in local economic structure, one which required a double-sided process of "centralization of capital":

- the structure of long-run assets and liabilities which is typical of heavy industry could only be created through import of capital (foreign direct investment or finance capital) and/or by some local centralization of funds obtained from old dispersed sectors; and

- some political-and-economic sphere (e.g. government) had to be able to centralize macroeconomic directions of capital accumulation, i.e. to strongly influence investment decisions, if the economy were to face that cluster of large and otherwise unattractive competitive challenges associated with late industrialization. Not only with respect to capacity-building investments, but also to local technological learning - which is an investment variable subject to firms' investment criteria as we saw before - it is worth attempting to observe any discernible patterns of relationships between centralized processes of financial centralization and decentralized investment decisions.

The following section bases on part one of the paper to sketch a framework which deals with technology owners' decision regarding its "externalized" or "internalized" modes of transfer. After proposing a general framework to understand negotiations of intangible assets among firms, we attempt to apply it to foreign firms' decisions regarding late industrializing countries.

II.2 Externalized Versus Internalized Transfer of Technology

In each market structure in which a firm owns technological capabilities (or other intangible assets) its strategy of market occupancy contemplates two distinct decisions:

(i) the volume of internalized operations, to which a level of investment - or disinvestment - in tangible assets corresponding to productive capacity is associated with; and

(ii) the volume of total operations, which is not necessarily equal to the former, inasmuch as the firm can rent or sell transferrable intangible assets without ceding market shares supplied with its own tangible assets. This is possible since any use of intangible assets does not preclude another simultaneous one, contrarily to the case of tangible assets.

Insofar as each one of the markets is concerned, the firm owns tradable and non-tradable capabilities, with the latter including the tacit parcel in the stock of operation capabilities which is only usable in intra-firm internalized forms.[6] In the same direction, Dunning (1988) distinguishes two types of firms' competitive advantages, i.e. "ownership advantages": (i) ownership of singular intangible assets and (ii) joint ownership of complementary assets. Whereas the former can usually be rent or sold, ownership advantages of a more collective type would hardly be tradeable - but with the sale of the firm as a whole.

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6 Tacit knowledge can be found at firm, plant or other disaggregated levels. We refer here to the first type.

The internalization/appropriation of technological capabilities - intra-sectorally or corresponding to vertical or horizontal integration - in previous moments must have been part of some strategy, possibly based on expected market and/or technological dynamics, as well as some "internalization advantages" (learning-by-interaction, guarantee of input supplies or sale outlets, lower competitive vulnerability in case of technological interdependence among sectors, etc.). When considering the possibility of commercial externalization of technology, the firm will take prevailing "internalization advantages" as an opportunity cost.

According to Dunning (1988), possible internalization advantages are derived from: (i) higher guarantee of appropriability of returns from each of the singular assets and (ii) synergistic advantages stemming from the coordinated use of complementary assets, subject to the cost of managing a more complex structure. The former corresponds to a benefit from lower vulnerability with respect to other firms, whereas the latter may be referred to gains accrued from the use of non-transferrable capabilities.

Trade of technological information - as intangible assets - has some peculiarities relatively to trade of tangible assets. For instance, neither the seller nor the buyer is able to perfectly anticipate the very end-product of the transaction. From the seller's standpoint, there is a risk associated with the possibility that the transaction may result in a higher-than-expected creation of capabilities by the purchaser. From the buyer's standpoint in turn detailed information regarding the merchandise may be tantamount to the technology to be acquired - Arrow's "information paradox". Technology purchase decisions are one of those innovative activities which were listed in part one, carrying on both technological and economic uncertainties. In the seller's side, anyway, the guarantee of appropriability of returns from each singular asset in the internalized use imposes the inclusion of some "insurance premium" in the price charged for externalization of technology.

Foregone net proceeds of internalized use plus that "insurance premium" make up the floor - in terms of supply price and restrictions to the use by receivers - upon which the owner accepts the technology sale or rent. On the buyer's side, a ceiling is given by the differential between expected net proceeds from the purchased asset and from its imitative reproduction (a positive ceiling by definition of competitive asymmetry). Transaction may occur as long as that ceiling for purchase is higher than the seller's floor, with the bargain fixing in some point along the range between them.

Another peculiarity of intangible assets, comes from the fact that legal or similar restrictions to the internalized use (exogenous to the negotiation) may simply push down sellers' floors - provided that there is no compensating effect on the "insurance premium" - given that additional cost of use of intangible assets is zero. On the other hand, depending on whether that premium is so high as to make externalized transfer impossible, restrictions to internalized use may simply result in technology unavailability.

One may infer that, among other factors, externalized modes of technology availability - for a certain sector or geographical market - will have increasing probability in the following circumstances:

(1) Assuming for each firm a positive correlation between debt-equity ratios and intertemporal rates of discount applied to internalized returns, externalized modes will be better appreciated by technology owners the higher is the financial leverage associated with the internalized use. In a given moment, such leverage tends to be larger in the case of second-tier firms and outsiders. If the structure of increasing intertemporal discount rates is similar along all firms

in the market, those second-tier and outsider firms will be more prone to externalization. For similar reasons, a deterioration in general conditions for finance favors externalized modes.

(2) The same will happen the smaller is the parcel of intangible assets which can only be used in the internalized way, i.e. the lower are Dunning's synergistic ownership and internalization advantages. The reference to the synergy is the whole set of intangible assets held by the firm in all markets in which it operates.

(3) The lower is the risk of non-effectiveness of sellers' expectations about the result of transfer or, in other words, the lower are internalization advantages associated with guarantee of appropriability of returns, the larger are the possibilities for externalized modes.

(4) Given that risk of expectation frustration, externalized modes will be more likely to take place the lower is the relative value of negotiated assets in the owner's portfolio and/or the lower is the risk upon survival of its set of ownership advantages. Given uncertainty, when it comes to a vital asset in the owner's portfolio structure the asymmetrically high cost of a transaction error (from the seller's standpoint) raises exponentially the "insurance premium" relative to the price of the merchandise.

(5) The higher are additional management costs associated with the extension of internalized use towards the market segment under consideration, the lower is its preference against externalization.

Technology trade presupposes a previous accumulation of technological asymmetries. Its possibilities are:

- sector-specific (varying with the tacit requirements of learning and with conditions for sustainability of appropriability);

- firm-specific (according to the relative value of the assets in the owner firm's portfolio, to owners' financial soundness and to its position in the ranking of competing firms since that position may define the relative magnitude of investments in tangible assets for the internalized use);

- region-specific (varying with the size of marginal costs of management under internalized use and with conditions of enforcement of contract clauses); and

- period-specific, inasmuch as parameters which define the appraisal of internalization and externalization change over time. In any case, one might expect that, *ceteris paribus*, a fall in expected value of firm-specific technological assets (due to a decline in dynamism of corresponding markets and/or to diminishing technological opportunity or appropriability) amplifies technology trade possibilities and reduces owners' bargaining power.

We believe that the simple framework here outlined can be useful in understanding the unprecedented widening of externalized transfer of technology to developing economies which occurred in the 1970s (Oman, 1984) (UNCTC, 1985). One could point out the influence of some macroeconomic and general technological movements which, according to our framework, may have led to lower internalization advantages. Even though this tendency was not sufficiently strong as to cross, in all firms and sectors, the frontiers of preferences between internalization and externalization, one might observe that:

(1) The degree of standardization in technological production capacities associated with "rigid automation" had already led the possibility of commercial transfer of technology via blueprints to its upper limit. Furthermore, the exhaustion of technological opportunity in most prevailing paradigms/trajectories reduced the synergistic advantages of internalization.

(2) Exhaustion of technological opportunity in those cases meant a reduction in "insurance premiums".

(3) The relative economic slowdown which prevailed in advanced economies along the decade aggravated problems with excess capacity and low income-elasticity of demand (and the number of branches afflicted with these problems increased). Consequently, internalization advantages also leaned towards lower levels.

(4) Exchange rate instability as well as a scenario of macroeconomic disequilibria led to a shortening in time horizon for investments (Oman, 1984: 79-70) which raised intertemporal discount rates present in estimation of proceeds from internalized use.

(5) The fiercing of competition at the international level in the 1970s corresponded to the entry into scene by many second-tier and outsider firms striving to extend their operations. Those firms not only had to cope with higher financial leverage to an internalized use, but also were prone to accept or propose externalized transfer as a means to bypass leaders (UNCTC, 1985).

(6) Last but not least, credit availability in the international private banking system during most of the 1970s meant a wider room for maneuver for technology purchasers in late industrializing processes in course.

Those sector- and firm-specific trends expressed themselves in different modes and intensities according to home countries: for instance, German and Japanese firms revealed a higher propensity to externalized transfer than their US counterparts (Oman, 1984: 80-4). In the Japanese case, our framework suggests that, besides any possible strategies regarding access to natural resources, firms' decisions in convergence with geopolitical state reasons or other determinants, one should consider that:

- given the typical high degrees of diversification and internalization of technological capabilities by Japanese conglomerates, the opportunity cost of externalizing second-tier products and activities became relatively low (lower risks regarding survival of their sets of assets and the possibility of centering on a hard-core of branches with high aggregate values);

- small-and-medium firms responsible for some of the Japanese transfer of technology in labor-intensive activities to neighbor regions (Oman, 1984) were clearly not prone to financial leverage; and

- trade surpluses with the main trade partners and protectionist threats made foreign location of some technological capabilities increasingly attractive even when externalized forms were favored by host countries.

Specificities of host countries regarding "externalized" and "internalized" forms of technology inflows reflected differences in historical timing and country characteristics. In the cases of South Korea and Brazil - the most advanced late industrialization experiences respectively in East Asia and Latin America (Canuto, 1992):

vulnerability - and it is qualitatively different from the one-sided technology transfer towards late industrialization experiences.[7]

In the final section we turn to local learning upon imported technology in late industrializing countries, taking the successful Korean experience as a reference.

II.3 Technological Learning in Late Industrialization: the South Korean Experience

South Korean heavy industrialization assumed under particular forms those historical characteristics shared by all late industrializing processes (Canuto, 1991b):

(1) The local discontinuity in capital accumulation processes was even higher than in Latin America because of the local capital structure inherited from Korean previous economic evolution. Instead of some noticeable capital accumulation from light industry and/or primary-goods exports as it was the case in various Latin American countries, in Korean economy there were only a highly pulverized land property structure since post-war agrarian reform and a less developed industrial accumulation.

(2) Foreign direct investment had a low participation as compared to Latin America and local private or state property was predominant, with technology inflows under externalized forms and with funding by the international private banking system.

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7 See, e.g., Hagedoorn (1992) for an empirical assessment of those "strategic technological alliances" as well as for their differences from "inter-firm technology transfer agreements".

(3) Centralized finance and investment decision-making was thoroughly realized within state, through a wholly public banking system which controlled most loanable funds originating locally or from abroad.

(4) In the course of heavy industrialization a cluster of highly diversified conglomerates - the *chaebol* - emerged, what was only made possible by extremely high debt-equity ratios sustained by a continuous roll-over by state banks. *Chaebol*'s presence spreads over most of the industry.

(5) A fast technological learning characterized South Korean heavy industrialization and indeed some "reverse learning" was revealed later on when the *chaebol* successfully entered some medium-to-high technology sectors in electronics and automobile industry.

Let us attempt to apply our framework to appraise some of the explaining factors which might lie behind that fast and far-reaching technological learning.

(A) <u>A Japanese bias in technology inflows</u>

The Japanese economy has been Korean largest technology supplier (Petri, 1988) - suggesting that Korea had a role in Japanese firms' strategies mentioned in the previous section. Given the forefront position attained by Japanese firms in production capabilities within most metallurgy and metal-working branches one might find there a starting advantage of Korean late industrialization as compared to other cases.

Notwithstanding the relevance of the Japanese bias, one should recall that local-and-specific knowledge is ubiquitous, even if with differing sectoral degrees. Furthermore, "reverse learning" could not be contained in the technology transfer.

(B)<u>Labor technical education</u>

Korean population's educational profile outstands relative to, e.g., Brazil and Mexico (not Argentina) (Canuto, 1991b: 50). Assuming that those statistics effectively represent a wider proportion of labor with a previous formal - scientific or technical - preparation to productive activities, South Korea had there another explaining source for its rapid technology absorption.

Nonetheless, labor formal education is not a sufficient condition for fast and "reverse" learning. Science and technology are not the same thing, as we saw in part one. The latter refers to a different type of activities and its tacit dimension can only be developed through "practice", i.e. through the exercise of technological capabilities at each firm level and containing a lower degree of articulation and codification than the former. Technical education, by its general and abstract nature, does not metamorphoses automatically into productive skills without enduring concrete experiences of production and innovation, since production processes comprise specific unities of human and material resources with selective capabilities accumulated along time. According to our framework - and contrarily to traditional "human capital" approaches which take it as an exogenous "factor of production" - there is no productive qualifying without corresponding exercise of capabilities.

Moreover, the social and institutional feedback exerted by educated labor employment and remuneration levels upon the general inducements to education within population reinforces the relative endogeny of skilled labor. Without the defiance to static comparative disadvantages of infant heavy industry there would not exist the famous Korean "pool" of skilled labor.

(C) State regulation of investments and technology transfer

Similarly to most industrializing developing countries in the 1970s, South Korea established a government apparatus to monitor technology transfer from abroad (Oman, 1984). The favorable scenario for mature-technology purchasing then prevailing, as we saw before, allowed efficacy in such regulation systems. They helped to push down towards the floor the terms of negotiation in many dealings.

In connection with state monitoring of technology transfer and absorption, one might mention the policy of sectoral regulation of investments as one of our explaining factors. Besides discretionary decisions regarding most loanable funds, government retained licensing as a precondition for production operations in heavy sectors. In the use of those prerogatives during exercises of (re)structuring, government emphasized (Enos & Park, 1988):

- minimizing the number of firms and/or maximizing specialization within branches in order to minimize scale problems which are typical of late industrialization; and

- the "staggered-entry formula" (an entry by stages) inasmuch as timely sequencing was possible. New plant building and some new product introduction were sequentially made, with or without new firms, according to targets of further technology absorption and in order to reap scale economies faster.

Those procedures resulted in local **structure** configurations - in terms of scales and learning opportunity - that were as less unfavorable as possible with respect to late insertion within international competitive contexts. However, as much as in the case of the previous two explaining factors, that modelling of local structures is not sufficient to elucidate Korean infant-industry "maturing", since the minimization of structural disadvantages had an outcome which also depended on the strategic behavior adopted by structure-composing agents, given the evolutionary character of competitive processes.

In late heavy industries, the rhythm and reach of learning - even if with solely respect to production capabilities - is a variable which depends on: local level of participation in all moments of transfer of technological information; man/hours of dedication to examining production engineering and quality control; remuneration of skilled labor; trials and errors; simultaneous sourcing of alternative supplies of technology; labor (re)training and many other aspects which involve costs and which ultimately are the subject of investment decisions regarding accumulation of intangible assets.

Difficulties associated with late heavy industrialization do not refer only to initial structural scale and learning gaps, but also to the need that local investment decision-makers consider as favorable *ex ante* the expected return from adoption of aggressive gap-reducing strategies. Insofar as maturing of the infant industry is concerned, government policies will be successful only to the extent that decentralized investment decisions converge - or are induced to converge - towards learning.

(D) The high diversification of Korean conglomerates

Did centralization of industrial property with the *chaebol* - involving technologically and/or commercially related branches but also unrelated ones - represent by itself a structural favorable feature in Korean industrialization?

A first remark is to be done regarding the possibilities of pecuniary scale advantages derived from typical *chaebol* financial size (not to productive scales or diversification of activities). To this respect, it is worth noticing that the Korean firms' strive to enter tough-competition markets in the 1980s - with own brand names - supposed a resource application that would be unthinkable were not for the possibilities of inter-branch shift of liquidity which *chaebol* present nowadays. One can say the same as regards their simultaneous joint-ventures with several Japanese, North American and European groups in electronics and other sectors. Nonetheless, until mid-1980s they were still growing and diversifying under financial and regulatory aegis of the state and it is not meaningful to include pecuniary scale advantages in our explaining factors for maturing.

A second possibility is related to technological scope economies, i.e. learning gains stemming from the firm's internalization of externalities among different activities that would not occur with other configuration of property of technologically connected branches.[8] One must not forget that scope economies can only be meaningful if there is some contiguity among branches. To this respect, the Korean conglomerates' ultra-diversification would not constitute an advantage with respect to, say, corresponding foreign firms with smaller sizes but sufficient diversification around a core of technologically contiguous sectors.[9]

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8 It must be kept in mind that we are hypothetically comparing two similar infant industrial structures, one of which presents a higher property centralization. We are thus not referring to economies of scale or scope of a given industrial structure as a whole *vis-à-vis* the rest of the world. On this matter, see Ocampo (1986).

9 We must make explicit that we are assuming in present considerations that learning gains through technological specialization can always be obtained by a diversified firm through organizational decentralization of activities. Therefore, an integrated firm has never a lower degree of learning opportunity than a corresponding set of independent and specialized firms, since the former additionally has the possibility of gains from scope.

Two remarks are nonetheless necessary:

(i) *chaebol*'s ultra-diversification ended up implying that sort of internalization with more frequency than in any other peripheral case; and

(ii) given the opportunities provided by the state industrial planning to enter distinct branches - and as we shall see linked by the government to rapid learning - Korean groups searched for developing a peculiar type of capability: general and partially transferrable abilities in feasibility studies, in formation of task forces, in equipment and technology negotiation, in plant building, in labor training and other aspects which would all comprise a "learning to fast learning".

In any case, both state regulation of investments and the ultra-diversification of Korean *chaebol* might have been inscribed in a large variety of evolutive trajectories. Indeed, one last aspect is required in order to fully grasp South Korean technological learning.

(E) <u>"Picking up winners and punishing losers"</u>

Along the 1970s the fate of capital accumulation and reproduction was traced within state in South Korea. By centralizing most loanable funds and providing subsidies and production licensing, the state defined who was to get into selected branches and who was to amplify/diversify capacities. In the very same process, it retained a strong capacity to steer capital shaping and to act as a last-resort judge on survival of existing portfolio structures. From capital insignificance in post-war period to firms with US$ 20 billion sales in 1987, one can find a strong discontinuity associated with heavy industry during most of which state dirigism prevailed almost absolutely.

According to reports by Enos & Park (1988), Amsden (1989), Chang (1990) and others, by looking backward one might localize what we may call a pattern of "helping winners and punishing losers" in the exercise of state dirigism. Taking into account some yardsticks such as compliance to financial contract clauses regarding export targets, production technology autonomization, local price reductions and/or higher quality, etc.,government decision criteria would have maintained a coherence as regards "carrots" and "sticks", one in which good and bad performances were respectively well rewarded and severely punished. For instance:

- the investment sequence along previously mentioned "staggered-entry formula" rewarded pioneer firms with monopoly maintainance or privileged new entrants according to the former's performance;

- industrial restructuring often involved some asset writing-off, especially in the case of bad management or strategical mistakes; and

- given the high financial leverage of firms in heavy sectors by state-owned banks and the corresponding need for continuous roll-over, falling into "disgrace" with government plans was close to a doom to bankruptcy and asset redistribution among competitors.

The highly politicized style of competitive selection implied:

(a) an *ex post* selection along which local industrial structures were increasingly occupied by most efficient firms in terms of learning; and

(b) at the *ex ante* firm level, high prospective net returns associated with investment in technological capabilities and with market occupancy locally or abroad, even when both investment and occupancy required short-run low profit rates, inasmuch as there was a clear disjunction: either to continue to grow under government privileges or to face the risks coming from loss of prestige.

As it was hinted in Section II.1, clues for understanding specific historical-concrete learning processes in late industrializing economies may be found in any discernible patterns of relationships between features of financial centralization and singular investment decisions. In the Korean case, the paucity of previous capital accumulation, the foreign credit availability which was characteristic of the 1970s, as well as the possibilities of technology access via externalized modes, all comprised a set of unique favorable conditions for the state design of industrialization by making financial and market-occupancy dynamics directly dependent on technological learning at the firm level as a precondition.[10]

The enforcement of economic policies does not depend exclusively on policy attributes but also on its capacity to shape private decisions. This is a general point that we believe to have become clear from the standpoint of the Post Keynesian evolutionary approach here suggested.

10 In Brazil, to cite the Latin American "paradigm" of late industrialization, a lower political and financial autonomy by the state led to a causation in a reverse way: in the case of non-natural-resource-based heavy industries, i.e. metal-working products, protection of local potentially dynamic markets was the only hope for inducing privately-decided technological investment.

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