

Revisiting Nelson and Winter from the South: "learning by solving" in underdeveloped countries

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"Among issues regarding the world economy today, none presents a more critical mix of promise and danger than those that reflect the wide disparities in present level of economic development and the strains that afflict societies struggling to catch up" (Nelson and Winter, 1982: 1).

Twenty years elapsed since the above statement was made; its validity is as strong nowadays as it was then. In the first section of this paper, we focus our attention on why the study of Nelson and Winter's book gives fundamental intellectual tools to address several critical development issues; some of those issues are analysed in the second section.

1.- Development problems seen through evolutionary approaches

The strains that afflict societies struggling to catch up include many "elementary" flaws, like those related to plain survival and minimum levels of quality of life. They also include severe difficulties to generate self-sustained virtuous circles of systemic behaviour directed towards problem-solving activities. These two types of difficulties and strains, which are seen in different degrees in almost all developing countries, recognise distinct historical roots and can be considered, to some extent, different in kind. They are, however, increasingly interconnected. Economic growth is an unavoidable requisite for development, and its uneven fate in underdeveloped landscapes is partly related to its problem-solving backwardness. Problem-solving activities promote self-sustained development when they are embedded in people's working routines, and this is hard to achieve in extremely unequal social conditions: "Social justice is not just a good thing in itself: it might be one of the most important long term prerequisites for a strong innovative capability in society" (Dalum et al, 1992: 316).

Evolutionary economics, as proposed twenty years ago by Nelson and Winter, even if it had not as a main concern to tackle development problems, provides nevertheless rich insights into such problems. The first and more comprehensive of those insights comes from the rejection of a set of well established simple assumptions about how social actors behave in economic life; such rejection, if relevant in "mature" societies, results even more so in underdeveloped ones. The approximation to real life conditions given by such a standpoint is complemented by a second general effort, the elaboration of concepts able to fill some gaps that earlier simplifications left aside from analysis. It is around this concept building effort, particularly when related to innovation, that the reflection on development issues gets the most from the seminal book that is being honoured.

1.1 Innovation as problem-solving

Actors of innovation are not only firms, but ultimately firms are those organisations which capabilities to innovate and willingness to innovate largely define the introduction of newness in any given modern society. The evolutionary approach concentrates on historical change and on the very basic attributes that constitute the Ariadna's thread allowing keeping track of techno-economic change.

...our firms are modeled as simply having, at any given time, certain capabilities and decision rules. Over time, these capabilities and rules are modified as a result of both deliberate problem-solving efforts and random events (Nelson and Winter: 4).

These deliberate problem-solving efforts are not exclusively devoted to innovation, but they include indeed innovation. As it happens with all kind of efforts, one thing is to undertake them and quite another is to succeed in obtaining what was intended. The main point here is the inclusion of innovation as part of the deliberate effort of problem-solving, although the results of those efforts are not guaranteed.

Our final point concerning the relationship between routine behavior to innovation is centered on a simple distinction between organizational activity directed to innovation (or problem-solving more generally) and the *results* of such activity. The fundamental uncertainty surrounding innovative activity is uncertainty about its results." [...]

"Routinized arrangements for producing innovations and solutions to problems take a variety of forms...Whether results are actually achieved is another matter. In fact, results that are more or less useful are often achieved –and it is an important feature of these problem-solving situations that the superior results that in some sense 'could' have been achieved are usually not available as a standard for comparison"(Id: 132, emphasis added, italics in the original).

Emphasis in the creative nature and non-calculable outputs of innovative activities is strong:

In the contemporary economy, some portion of business behaviour is closely calculated by sophisticated optimisation methods. Another portion is innovative activity shaped by the creative problem solving insights of scientists, engineers and managers (Id: 135).

Finally, innovative activities understood as problem solving imply searching for solutions, and

[searching] is distinguished by what we may term its *contingent* character. Real search processes take place in specific historical contexts, and their outcomes clearly depend in part on what those contexts contain in the way of problem solutions that are available to be 'found'. What there is to be found consists in large part of the fruits, by-products, and residues of information-producing activities elsewhere in society. The flow of general social history thus impinges directly on the firm through its search activities, and searching at t is not the same thing as searching at $T > t$ (Id: 172).

Why are such "evolutionary insights" so important for thinking about development? Three main reasons can be given. The first one relates to the fact that problem-solving activities are indisputably internal to the firm: its capabilities are modified over time partly because it undertakes deliberate efforts directed towards creatively solving problems. Firms must surely rely on "imported" innovations; small and medium enterprises, poorly endowed with highly trained personnel, will probably rely heavily on solutions designed elsewhere. But the extent to which they could find "external" solutions and also the quality and well fitting of the found solutions are influenced by their own problem-solving abilities. ["In a great many situations, the effectiveness of planning and implementation by an individual who will not ultimately do the thing himself is considerably enhanced by possession of some level of the required skill, as a complement to knowledge of the skill name" (Id: 87).] The importance of these abilities for the firm's evolutionary paths is frequently underestimated in developing countries. Changes and modernisation are mainly seen as "external shocks" that require much more adaptation abilities than creative capabilities. This vision informs policies in many ways, and leads to underestimate some important mechanisms for strengthening the problem-solving musculature of firms. This is an example of theoretical weakness and not so much an example of the difficulties for implementing policies derived from good theoretical insights (both being part of underdevelopment pitfalls): firm's problem-solving capabilities do not enjoy the theoretical status that evolutionary thinking assigns them.

The second reason why those "evolutionary insights" are so important from a developmental point of view relates to the separation between innovation and problem solving as purposeful activities, on one side, and the outcomes of such activities, on the other side. Sometimes what is intended is found and sometimes not, but "results that are more or less useful are often achieved". In developing countries, partly as a consequence of the way in which industrialisation evolved, obtaining short term results appears as paramount and it is difficult not to perceive as a failure the possible non-fulfilment of the

planned outcome. Perhaps too much insistence on the inherent uncertainty of a problem-solving undertaking would lead to recommend avoiding addressing it. However, it is generally correct that trying to solve problems, even if solutions are not found or are not totally satisfactory when founded, gives its own rewards. Sometimes through serendipity, sometimes because it allows better chances for a second trial or for identifying good partners to rely on. Problem solving, in real life, is a bet, often worth undertaking beyond its results, and this is as well valid -or perhaps especially valid- in underdevelopment.

Finally, the conceptualisation of innovation as problem solving allows, through searching –an activity always connected with innovation- to introduce the “outside world” quite naturally and in direct contact with the firm’s behaviour. Context matter, for the possibilities to solve problems is in part determined by the available solutions that can be found in a given context. This is a very concrete way to underline that firm’s capabilities to innovate are related to the searching activities in society at large. These are difficult to improve in developing countries, for they are slowly evolving variables, and because the related capabilities are quite vulnerable to the many assaults of bad conjunctures. The evolutionary argument for taking care of the general conditions for “solution searching” is particularly pertinent in underdeveloped landscapes, however complicated to follow it might be.

1.2 The central issue of capabilities, of how they evolve and for what kind of actions they are necessary

There is a universal acknowledgement about the crucial importance of capabilities, of enhancing them, of assuring that weak actors, be they persons or organisations, will get a minimum endowment of capabilities allowing them to operate in society. It is also acknowledged that capabilities and knowledge are two intimately related concepts. However, what exactly capabilities are, how can they be improved and to perform what are they necessary is not so clear. As usually happens with concepts belonging to social sciences, they belong also to “common language”, which endow them with ambiguity and vagueness.

If we concentrate on technological capabilities and on the type of knowledge that form the bulk of technical innovation, things do not get any simpler:

It must (be taken) into account that technology is born of society –that it is a ‘social construct’; that any particular episode of technological innovation and change is, frequently, dependent on the personalities, visions, and idiosyncrasies of its principal protagonists; that the choices and decisions that determine the pathways of technological history are contingent upon the structures of power and patronage that prevail in organisations and institutions; and that technical change is inextricably tangled amid the web of economics, commerce, and the profit motive (Dasgupta, S., 1996: 180).

Nelson and Winter rise some central questions related to capabilities:

What is really involved when a organisation is ‘capable’ of something?; How does an organisation remember its capabilities?; What is involved in ‘choosing’ to do one thing rather than another?; What kind of capabilities are involved in choosing?” (Nelson and Winter: 52-53).

“What determines a firm’s production set? Why is it what it is?...Arrow and Hahn are quite explicit: ‘The production possibility set is a description of the state of the firm’s knowledge about the possibilities of transforming commodities’...What is the nature of this knowledge? (Id: 60).

If ‘technological knowledge’ is what defines a firm’s capabilities, where in the firm does that knowledge reside? What rationale can be given for the presumption that there is a sharp boundary line between what a firm can and cannot do? How does the knowledge possessed by one firm relate to that possessed by others, and to the ‘state of knowledge’ in the society generally? (Id: 62).

Part of the answer of some of those questions is that firm’ capabilities and the knowledge they possess is not just the sum of what their members have:

...the possession of technical ‘knowledge’ is an attribute of the firm as a whole, as an organised entity, and is not reducible to what any single individual knows, or even to a single aggregation of

the various competencies and capabilities of all the various individuals, equipment and installations of the firm (Id: 63).

This can be clearly understood if it is acknowledged that capabilities and knowledge are permanently in flux and that their patterns of change do not rely exclusively on abstract matters, like studying a new advance of science or getting acquainted with a new technological direction. Individuals' capabilities and knowledge improve that way, but also by deliberately trying to solve problems, a process during which not only "old" knowledge and capabilities are applied but also "new" ones are acquired. Problem solving is "organisational dependent": for some firms these activities may mean an unwelcome departure from productive routine, while for others they can be taken as the key for smoothly productive routines as well as for fresh insights into "new combinations". These differences are partly a result of the type of activity undertaken: the intensity of problem solving and the deepness of changes in capabilities and knowledge would probably be widely different in modern biotechnology and in shoe making. But differences are also originated in the organisational personality of firms, beyond its specific productive activities, something that is itself subject to changes.

What can make some firms more active in promoting capabilities upgrading and knowledge acquisition through problem solving? Opportunities and incentives to face new challenges can be reasonably included in the answer. This implies that not only the transformation of individual capabilities into a firm' upgraded collective capability depends partly on conditions provided by the firm, that are external to the individual, but also that the firms' disposition to undertake problem-solving activities depends partly on their external environment.

Such conclusion is quite important from a developmental perspective, for it comes to say that firms organisational personality is socially embedded, or that the capabilities a firm is able to achieve are dependent to some extent on the richness of problem solving opportunities that society provides. In a sense, something related to that is what Christopher Freeman argued when he wrote:

In the long run, how much one wants to rely on imitation, licensing and purchasing know-how, and how much one wants to rely on one's own problem-solving capabilities, will depend partly on what kind of society one wants to live in (Freeman, 1992: 48, first published in 1967).

The discussion about the differences between capabilities for doing and for choosing is perhaps a subtle one, but from a developmental point of view it is an important discussion. The way evolutionist approaches address this issue is particularly well suited for that standpoint.

Orthodox theory makes a sharp distinction between the choice set and choosing –between what is involved in operating a particular technique and what is involved in deciding what technique to use. In our evolutionary theory we see strong similarities in these" (Nelson and Winter: 15). "...there is no sharp line separating the performance of actions from the choosing of actions (Id: 21).

One of the reasons for blurring the frontier between choosing and performing is the hypothesis that choosing receives feedback from performing to such an extent that it is difficult to neatly separate one activity from the other.

A concrete example can illustrate the point. In the seventies, in Uruguay, a young professional electronic firm producing telex central exchanges had to decide whether to build the next series of devices with the already mastered technology of 16 bytes microprocessors or, instead, shift to the much newer one of 32 bytes, the option that was finally retained. Relying on the old technology was safer and allowed a rapid response to demand; it also implied not to profit from an already signed contract to make more comfortably the shift to a technology that in a near future would result mandatory. The engineer-owner of the firm, reflecting on the characteristics of techno-economic decision-making, was quite emphatic in stating that this was an example of a type of decisions very hard to make without technical knowledge and production experience.

In such case, the kind of considerations that emerged in the discussion could have been captured by the following remarks:

Finally, the occasions of choice are often opportunities for the clarification and elaboration of goals. Questions of 'what we are trying to accomplish here' often come in for active consideration, not in the mode of logical deduction from premises accepted in the past, but rather in a mode that

recognises the specifics of the choice situation as posing issues of general direction, balance and trade-offs that had not hitherto been confronted (Nelson and Winter: 69-70). More generally: “The above discussion suggests that ability to deliberate and implement are elements of a firm’s capabilities...the separation between capabilities and choosing becomes suspect. ..The questions we have raised about the knowledge that underlies capabilities are as relevant to capabilities of choosing as they are to capabilities for producing” (Id: 71).

In many circumstances, choosing, even more than producing, is an activity where asymmetry in the relevant knowledge possessed by those that have to choose and those who offer the choices is considerable. In developing countries, where process innovation and product innovation come overwhelmingly from imports and licences, these asymmetries have frequently been a source of distortions and inefficiencies. Moreover, as everywhere else, the main system of incentives for salespeople push them not to encourage dialogues but to put forward the question “What can I sell you from my present products?” (von Hippel, 1988: 119). Dialogues about what is really needed, and so, about what the real terms of the choices are, can be established more seriously when the “knowledge asymmetry” is lower. Producing gives useful insights that help in that direction, particularly when the way of organising production allows for routinely problem-solving activities. Thus, the evolutionist’ rejection of a sharp separation between the choosing of actions and the performance of actions can be echoed, in a development perspective, by stressing the inadequacy of separating too harshly choosing technologies from building own technological capabilities.

1.3 The rejection of the “effective procedure” hypothesis for firm behaviour

Joseph Weizenbaum, a former Director of the MIT Computer Sciences Department, defines “effective procedures”, also called algorithms, as “a set of rules which tells us in precise and unambiguous language what to do from one moment to the next” (Weizenbaum, 1976: 67). What are the issues that can be properly tackled by effective procedures? According to Weizenbaum, typically those that could fulfil two conditions: first, that related behaviours obey rules such that there exists a language in which they can be stated in a precise and unambiguous way; second, that all people are identical in every respect having anything to do with the issue (Id: 47). Cooking is clearly, as the same author states, an issue that cannot be tackled by effective procedures, precisely because neither of those two conditions hold. Blue-prints are very much like effective procedures: they are intended to tell in precise and unambiguous language what to do from one moment to the next. The hypothesis that the behaviour of the firm –particularly technological behaviour- can be modelled through an effective procedure is not tenable, for the very same reason invoked in the cooking case: such behaviour does not fulfil the necessary conditions. Nelson and Winter’s book (p. 119) quotes the following remark of Michael Polanyi concerning this point:

The attempt to analyse scientifically the established industrial arts has every where led to the same results. Indeed, even in modern industries the indefinable knowledge is still an essential part of technology. I have myself watched in Hungary a new, imported machine for blowing electric lamp bulbs, the exact counterpart of which was operating successfully in Germany, failing for a whole year to produce a single flawless bulb.

Nelson and Winter themselves stress the fact that “...the creation of productive organisations is *not* a mater of implementing fully explicit blueprints by purchasing inputs on anonymous markets...” (Id: 119). The importance of that statement for development concerns cannot be overstated. Too often, international organisations as well as governments and firms in developing countries speak and act as if “technology transfer” was the answer to productive backwardness. Too often, also, “technology transfer” is understood as purchasing devices and getting advice by reading and understanding the correspondent manuals. “But just as an individual member does not come to know his job merely by mastering the required routines in the repertoire, so an organisation does not become capable of an actual productive performance merely by acquiring the ingredients’, even if it also has the ‘recipe’ ...” (Id: 102).

If this is true for already known technologies, it is even more so for problem-solving activities. In underdeveloped countries, it is not at all unusual to assimilate problem solving with finding a ready made

solution somewhere and then proceeding to “technology transfer”. The underlying hypothesis is that the developed world has become a huge technological supermarket where everyone with the required amount of cash can find the solution to almost every problem, or the consultants able to find the solution if it happens not to be already available. The evolutionist rejection of the “effective procedure” hypothesis is mirrored by the “developmental” rejection of this underlying hypothesis.

A clear example of the last rejection is the position held by Edgar Pisani, a former commissioner of the Lomé Convention:

Whoever transfers a technology, transfers at the same time a problem, a method of reasoning, a fixed capacity and a power, and whoever receives a technology, is obliged to convert it accordingly to a requirement which is not their own. Instead of looking to the transfer of technology to ensure their development, the Third World countries should be looking into the appropriation of techniques, that is to say mastering and adapting them. One only really masters a technology which one has invented or re-invented oneself (Pisani, 1984: 179; our translation)

In developing countries, “evolution” is often jeopardised by excessive reliance on the “how.to.do.it” (Nelson and Winter) type of recommendations that usually come with technology transfer.

1.4 Knowledge and learning as keys to innovative behaviour

Change is an essential issue in evolutionary economics and in development thinking. In particular, evolutionary economics analyses changes in production and in knowledge as intimately interrelated phenomena, connected through learning processes and giving rise to further changes, some of which can, eventually, reach the status of innovations.

What real considerations could produce a sharp boundary between ‘technically possible’ and ‘technically impossible’ production activities? ...The boundary is the boundary of knowledge (Nelson and Winter: 63)

But who has that knowledge? If we agree that “‘knowing’ is something that only humans can do” (Nelson and Winter: 105), the answer can either be individuals in the organisation that is trying to stretch the limits of what is technically feasible or individuals in a separate organisation that possesses the relevant knowledge and is willing to transfer it. The evolutionary point of view stress not so much the fact of having knowledge but the capability to be an agent in the change of knowledge, that is, an agent in the process of learning. In this sense, endogenous efforts towards increasing somehow the organisational “knowledge capital” is always present there where change in knowledge occurs:

Whatever ‘knowledge’ means in the organisational context, the state of knowledge is certainly subject to change. It is subject to change by deliberate choice, as when effort is exerted to discover the answer to a specific question, and it is subject to change by unchosen and unwelcome processes, as when an explosion or breakdown signals the unfeasibility of an attempted course of action” (Id: 63-64). “It is subject to increase [...]. An attempt to improve it may be a matter of looking up the answer in a source known to contain the answer, or an extended search for a problem solution that may not exist (Id: 64).

The idea that the boundary between what is technically feasible and what is not in a given organisation is a boundary of knowledge is particularly important for development thinking. This idea stresses again the fact that “knowledge shortcuts” to changes in performance given by blue-prints, equipment, licences, technical advice and the like are not enough to assure a better performance. The efforts to build competence through learning cannot be avoided, says evolutionary economic theory, warning repeatedly against positing formalisms to which no behavioural reality corresponds.

The concept “boundary of knowledge” is quite concrete, and has to do with what people know. However, this general statement deserves a cautionary remark: particular attention should be paid to what formally trained people know. This could not have been so during the early times of the Industrial Revolution but it is indeed so in the late 20th century. Nelson and Winter’s comments on natural trajectories, a key concept in their theoretical framework, relate to the boundaries of knowledge through a

cognitive approach: natural trajectories have to do with “technician’s beliefs about what is feasible or at least worth attempting” (259). Moreover:

One aspect of natural trajectories, whether specific to a particular technology or more in general, whether of the nineteenth century or contemporary, is that underlying the movement along them is a body of knowledge held by the technicians, engineers, and scientists involved in the relevant innovative activity. ...But in the middle of late twentieth century, many scholars have been tempted by the hypothesis that underlying the technologies that have experienced the most rapid advance (or built into a key component of these) is a relatively well-articulated scientific knowledge. This does not mean that the ‘inventors’ are active scientists or that ‘inventing’ exploits knowledge produced by recent science. But the fact that college-educated scientists and engineers now comprise the dominant group doing applied research and development indicates that, at the very least, scientific literacy is an important background factor (Id: 261, 262).

Therefore, the competence to innovate or to solve problems seems to be anchored largely in formally trained scientists and engineers. Some times, scientific and technological competence is applied to imitation. Is imitation, so often present in developing countries, a “second rate” technical activity? Evolutionary answer is as follows:

An imitator working with an extremely sparse set of clues about details of the imitatee’s performance might as well adopt the more prestigious title of ‘innovator’, since most of the problem is really being solved independently. However, the knowledge that a problem *has* a solution does provide an incentive for persistence in efforts that might otherwise be abandoned (Id: 124).

This statement could have been written when thinking about concrete situations in developing countries. There, it often happens that something which is needed for applying a “canonical” way of solving a problem is missing, be it a measurement instrument, a component, a type of synthetic product or any other “ingredient” of an already known way of solving a problem. It is essentially correct to qualify people able to solve problems in such conditions as innovators, even if what they really do is a mixture between imitating and inventing ways to substitute the missing factors. Some times, moreover, these inventive ways to overcome restrictions give rise to truly new devices or procedures with a life of their own. These situations appear so often in underdeveloped landscapes, that the related solving problem activities deserve a specific denomination; we propose to name it “capacity to innovate in scarcity conditions”. Those that could reject the term “innovate” given that eventually little essentially new is produced should be reminded that this most prestigious denomination is well deserved given that important parts of the problem have been solved independently.

It also deserves to be underlined that to innovate or to solve problems in scarcity conditions can be as heavily related to knowledge as if performed in more richly endowed environments. In this sense, the evolutionist conceptualisation around knowledge, learning and innovation is general in scope, being particularly useful to study and analyse development problems.

2.- On evolutionary problem-solving in underdevelopment

Having discussed - very briefly indeed - the relevance for development issues of several aspects of the evolutionary approach, we turn to consider some features of underdevelopment from an evolutionary point of view.

2.1 Development theory as an evolutionist approach

We may start by locating development theory in the general frame proposed by Clark and Juma (1988: 198-199):

[There] are major ideas and ‘visions’ which organise the development of scientific models, the nature of the theoretical ‘abstractions’ made, the choice of variables, the ‘facts’ that are held to

require exploration, and the heuristics guiding ‘scientific progress’. One can discern many examples of such ‘visions’ which have influenced the ways economists have tried to model the temporal growth of economic systems and whose characteristics may be seen in dialectical terms.

For example, a ‘short term’ perspective stresses the properties of the economic system *given* an unchanged parametric structure (in the neo-classical formulation, the ‘givens’ are the so-called ‘fundamentals’ - technologies and tastes). To a considerable extent the short-term perspective coincides with ‘static’ analysis. Conversely, the ‘long-term’ perspective centres on dynamics and changing structures (including, of course, technologies, institutions, beliefs and behaviours). A second example [...] lies in the dichotomy between an ‘equilibrium’ and an ‘evolutionary’ perspective. Such a dichotomy is partly related to the relative emphasis on the *result* of the process compared to the process itself. However, it is more than that, and in the history of economics the former vision has often implied an almost exclusive attention to the existence and properties of equilibria and equilibrium paths neglecting completely the question of how precisely the system gets there. On the other hand, the ‘evolutionary’ perspective places attention on a careful definition of the relevant processes (selection, innovation, etc.)

A third dichotomy [...] is the tension between ‘mechanistic’ and ‘organic’ visions of the behaviour of economic systems. Essentially, the ‘mechanistic’ view entails the belief that the ‘whole’ can simply be described in terms of properly quantifiable and stable equilibrium relationships amongst its constituent ‘parts’ [...]. On the contrary, the ‘organic’ vision argues that the ‘whole’ cannot be reduced in this way, but rather the properties of complex systems evolve from non-linear interactions amongst its components and ‘disequilibrium micro-states’.

Concerning such classification, it can be said, in general, that development theory, since it is concerned with the long-term dynamics, has to build evolutionary and organic perspective of social change.

Moreover, two of the greatest development economists, Albert Hirschman and Amartya Sen, share with Nelson and Winter some fundamental emphases, as the following: dissatisfaction with the neo-classic or orthodox approach; the central importance of the concept of capabilities and learning; the special relations between routines and innovation, at the same time opposite and complementary.

It can be noted also that several leading scholars of developing theory, as those just mentioned and others, seem to share the world view of evolutionary theory: “The world seen by evolutionary theory differs from an orthodox world not only in that things always are changing in ways that could not have been fully predicted, and that adjustments always are having to be made to accommodate to or to exploit those changes. It differs, as well, in that those adjustments and accommodations, whether private or public, in general do not lead to tightly predictable outcomes. For better or for worse, economic life is an adventure.” (Nelson and Winter, 1982: 370) And even more, so is development.

In what follows, we shall try to be more specific by referring to some points of view elaborated by Hirschman and Sen, that allow to present development economics as an evolutionist approach, in the same vein that many of the insights in Nelson and Winter’s book can be taken as “development” approaches.

For example, development according to Hirschman depends not so much on finding optimal combinations of productive factors and resources as on using - for development tasks - resources and capabilities that are hidden, scattered or badly utilised. (Hirschman, 1958 [Spanish version, p. 17]) Consequently, underdevelopment is essentially a state where important potentials for development are not used, mainly because collective views concerning change do not favour the adoption of adequate development decisions ([Id., p.36]).

The lack of decision-taking can be exemplified by the lack of investment capabilities, that is, capabilities for fostering the productive investment of existing or potential savings; such capabilities are increased by exercising them ([Id., p.45]).

This emphasis on decisions is related with Hirschman’s theory of unbalanced growth, one of the central issues of the book we are referring to, as pointed out by Paul Streeten (quoted in Meier, 1976: 645):

If balanced growth stresses *markets* as the main limitation to growth, unbalanced growth in the Hirschman version stresses *decisions*. The implication of Hirschman’s theory is that supplies will be forthcoming with relative ease if only the lack of decision-taking can be overcome. [...] Hirschman has been charged with excessive preoccupation with *investment* decisions. Much of his book indeed

focuses attention on them, but it is clear that he had a wider concept in mind, as is shown by his use of the terms ‘development decisions’ and ‘development tasks’.

Summing up, successful development appears as a learning by doing process, where different actors learn in practice how to make decisions and use potential resources for development tasks.

Such view stresses the role of backward and forward linkages. In fact, Hirschman (1981 [Spanish version, pp. 102-103]) asserts that development is essentially an indicator of the smooth operation of a series of linkages allowing situations to give rise to other situations; these linkages are focused on certain characteristics of productive activities already in operation at a given moment that are able to push –or to invite- some operators to pursue new activities. Summing up, linkages induce innovations. Hirschman says that his generalised linkages approach is a type of “micro-Marxism”, because it highlights the characteristic features of technologies and productive processes in order to understand social facts, but focusing on shorter periods and smaller regions than Marxism; this approach invites scholars to pay special attention to technological innovations that may have important economic and socio-political consequences (Id., 119 and 126). So the linkages viewpoint leads, in particular, to analyse concrete situations in order to see if economic and technological activities are such that one thing takes or not to another thing, that is, if they promote development. (Hirschman, 1986 [Spanish version, pp. 77])

If *linkages* can be seen as a key-word in Hirschman’s view of development, *capabilities* is the leading notion in Sen’s view, as we now recall, also in an extremely brief way.

We start from his analysis of Hirschman’s famous paper “The Rise and Decline of Development Economics”, which Sen describes as an “illuminating essay”. His own conclusions are also illuminating. He asserts that “traditional development economics has not been particularly unsuccessful in identifying the factors that lead to economic growth in developing countries. In the field of causation of growth, there is much life left in traditional analyses.” Nevertheless, “traditional development economics has been less successful in characterising economic development, which involves expansion of people’s capabilities. For this, economic growth is only a means and often not a very efficient means either.” (Sen 1984: 504)

The distinction between economic growth and development was central in Latin American political and academic debates from the 1950s to the 1970s, but was almost forgotten by prevailing trends since the 1980s and the early 1990s; reality seems to be pushing it back to the forefront.

Sen asserts that “the process of economic development is best seen as an expansion of people’s ‘capabilities’. This approach focuses on what people can *do* or can *be*, and development is seen as a process of emancipation from the enforced necessity to ‘live less or be less’. The capabilities approach relates to, but fundamentally differs from, characterising development as either (1) expansion of *goods and services*, or (2) increases in *utilities*, or (3) meeting *basic needs*.” (Sen, 1984: 510)

In this view, “economic development has much to do with making structural changes to conquer the inequities and exploitations that characterise the world” (Id.: 512). Development as a set of profound or “structural” changes was also the classical Latin American view, replaced in the later prevailing views by “structural adjustment”, which has a quite different meaning, theoretically and practically.

The emphasis on capabilities is closely related with overcoming inequities because it is asserted that “this capability perspective can be used not just for evaluating equality, but also for assessing efficiency” (Sen, 1995: 143). Moreover, “the reorientation from an income-centred to a capability-centred view gives us a better understanding of what is involved in the challenge of poverty.” (Id.: 151)

Now, the capability-centred view opens the way to building an integrated approach to development problems. To do that was a central recommendation of Hirschman (1981) in his *Essays in Trespassing*; there, in an already mentioned paper, he asserted that the decline of development economics is unavoidable without “trespassing” disciplinary frontiers. Sen (2000: 8-9) proposes:

... to investigate the development process in inclusive terms that integrate economic, social and political considerations. A broad approach of this kind permits simultaneous appreciation of the vital roles, in the process of development, of many different institutions, including markets and market-related organisations, governments and local authorities, political parties and other civic institutions, educational arrangements and opportunities of open dialogue and debate (including the role of the media and other means of communication).

Such an approach also allows us to acknowledge the role of social values and prevailing mores, which can influence the freedoms that people enjoy and have reason to treasure. Shared norms can influence social features such as gender equity, the nature of child care, family size and fertility

patterns, the treatment of the environment and many other arrangements and outcomes. Prevailing values and social mores also affect the presence or absence of corruption, and the role of trust in economic or social or political relationships. The exercise of freedom is mediated by values, but the values in turn are influenced by public discussions and social interactions, which are themselves influenced by participatory freedoms. Each of these connections deserves careful scrutiny.

Such a broad approach seems to be essential for policy-making, and is closely connected with the initial assertions of Nelson and Winter (1982: 371) in the chapter on “The Evolution of Public Policies and the Role of Analysis”:

Public laws, policies, and organisations are an important part of the environment that shapes the evolution of private sector activities. Laws and policies regarding what is patentable and what is not, and about acceptable or required licensing agreements, influence the relative advantages of innovating and imitating. Antitrust law and its administrative and judicial interpretation define acceptable competitive behaviour. Regulatory regimes constrain and mandate certain public actions. Public school systems and educational support programs influence the flow of trained personnel into research and development activity. Government R&D support programs have, since World War II, provided approximately half of the total funding for research and development. More generally, a significant portion of economic activity is conducted by public rather than private organisations. The evolution of economic capabilities and behaviour must be understood as occurring in a mixed economy.

The last assertion, in spite of the great changes of the late XX century, has not lost its centrality for development issues.

Returning to Sen’s approach, what is seen from the capability-centred point of view is *Development as Freedom*. Specifically, underdevelopment is “seen broadly in the form of unfreedom”, while development is “seen as a process of removing unfreedoms and of extending the substantive freedoms of different types that people have reason to value” (Sen, 2000: 86).

2.2 Problem solving and National Systems of Innovation

Coming back to the characterisation of innovation as a solving problem activity, it can be said that “solving problems” is a too aggregate category, at least when examined from a development perspective. The solving problem routines in a firm involve three distinct moments: the moment of identification, the moment of searching for solutions, and the moment of implementing the found solutions. The first and the third moments are eminently internal to the firm, while the second moment requires, more often than not, interactions with the “external world”. Here is when the concept of National System of Innovation fully enters the scene: the efficiency of the search for solutions activity depends on the strength of the R&D systems, the ability of that system to interact with industry, the human resources endowment of firms, the local tradition regarding the “made or buy” dilemma, the public support available to technical activities in firms (Johnson and Lundvall, 2000).

The National Systems of Innovation conceptualisation (Lundvall, 1985, 1988, 1992; Freeman, 1987; Nelson, 1993; Edquist, 1997) is particularly useful to tackle the “problem-solving issue” for at least three main reasons:

- (i) it explicitly acknowledges the political as well as institutional and cultural aspects of innovation processes, thus contributing to integrated approaches to development problems;
- (ii) it stresses the importance of interactions between actors and organisations providing for them a sound analysis framework, particularly useful for studying the evolution of linkages as indicators of development in Hirschman’s sense;
- (iii) it takes into account multiple actors with different roles, allowing to go beyond the dichotomy “state or market” regarding rule setting mechanisms, and making room for more “bottom-up” and associative networks.

Those features are particularly relevant in “the user-producer approach” and in its focus upon learning processes. In this ‘vision’, a particularly important role is assigned to usually neglected collective actors. For example (Lundvall, 1988: 365):

The classical actors in innovation studies are individual entrepreneurs and the R & D laboratories of big firms. Secondary parts may be played by scientists and policy-makers. The user-producer approach points to the fact that ‘final users’ in terms of workers, consumers and the public sector may have a role to play in relation to innovation. [...]

Further, the actual participation of ‘final users’ may be underrated in the literature on innovation. Workers play an important part in the daily learning processes taking place in production and many incremental innovations may be the product of skilled workers improving on the process equipment. Where workers are directly involved in the process of innovation, the outcome in terms of productivity and efficiency might be more satisfactory than when they are excluded from this process. Some studies of the Japanese experience seem to point in this direction.

It can be said that the National Systems of Innovation conceptualisation is closely dependent on “the importance of agency (seeing people as agents rather than patients)” (Sen, 2000: 137), that is the cornerstone of the capability-centred view of development as freedom. In fact, this is an *instrumental* as well as a *normative* characterisation of development: “Freedoms are not only the primary ends of development, they are also among its principal means.” (Sen, 2000: 18) The instrumental perspective highlights the role of “five distinct types of freedom” that include “(1) *political freedoms*, (2) *economic facilities*, (3) *social opportunities*, (4) *transparency guarantees* and (5) *protective security*. Each of these distinct types of rights and opportunities helps to advance the general capability of a person.” In this view, “the instrumental freedoms links with each other and with the enhancement of human freedom in general.” (Id.) Thus, an “activist” view of Development is presented: “this freedom-centred understanding of economics and of the process of development is very much an agent-oriented view” (Id: 11).

Thus, the characterisations of development we have been considering and the National Systems of Innovation approach converge to an actor-centred perspective.

In order to briefly elaborate the last assertion, we refer to Sen’s “distinction between two general attitudes to the process of development that can be found both in professional economic analysis and in public discussions and debates. One view sees development as ‘fierce’ process, with much ‘blood, sweat and tears’ - a world in which wisdom demands toughness. [...] This hard-knocks attitude contrasts with an alternative outlook that sees development as essentially a ‘friendly’ process. Depending on the particular version of this attitude, the congeniality of the process is seen as exemplified by such things as mutually beneficial exchanges (of which Adam Smith spoke eloquently), or by the working of social safety nets, or of political liberties, or of social development - or some combination or other of these supportive activities” (Sen, 2000: 35-36).

In a previous work, Sen had baptised these two contrasting attitudes as BLAST and GALA, respectively. The first acronym stems from Churchill’s invocation to “blood, sweat and tears”. The second one is meant to denote “a focus on people’s helping each other and themselves, and with being able ‘to get by with a little help from their friends’ (to apply a phrase from the Beatles)”, so the corresponding attitude to development is called “getting by, with a little assistance (Sen, 1997: 533-534).

BLAST can assume very different and even contrasting forms; one extreme example is given by the Soviet strategy for industrialisation, but this general outlook inspires divergent views of what must be done and not done; the last “can include having social safety nets that protect the very poor, providing social services for the population at large, departing from rugged institutional guidelines in response to identified hardships, and favouring - ‘much too early’ - political and civil rights and the ‘luxury’ of democracy.” (Sen, 2000: 35) BLAST views reflect “the centrality of capital accumulation”, that was “an enduring characteristic of post-war development economics”; the corresponding policies are usually presented as a choice for the future in “the conflict between present welfare and future welfare”, but such option has to be reconsidered “when economic productivity is seen to depend also on education, health care, nutrition, and the like” (Sen, 1997: 535, 536).

Thus, BLAST can be state-centred or market-centred, but GALA seems to be necessarily actors-centred, since it focus on the agency of people, on what they do and how they interact and co-operate, on the enhancement of their individual and collective capabilities, on the instrumental role of agency.

It is our content that GALA-type strategies have a chance of coping with the new challenges for development, stemming from the globalising knowledge economy, only if they also foster endogenous learning and innovation capabilities. That is, GALA views have to be combined with the National Innovation Systems (NIS) approach, with its emphasis on learning by interacting, and, more generally,

with its interactive, systemic and distributed characterisation of innovation. Together, GALA and NIS sketch an actors-centred approach to development.

2.3 Capability building as “learning by solving”

Problem-solving capabilities are special in relation to the ways people acquire or build such capabilities. They include indeed formal training, given particularly the growing importance of specialised knowledge in almost any kind of problem solving activities. However, formal training alone does not assure the growth of those capabilities. They must be developed through the application of whatever knowledge a person or an organisation can mobilise with the aim of solving problems. The term “learning by solving” is proposed in order to capture the specificity of the process of building such capabilities.

Nothing radically new is involved with this term: like other characterisation of how organisational and technical learning in firms and other places proceeds -learning by using, by searching, by interacting- this one makes explicit an implicit or tacit attribute of the learning process. Its interest lies in stressing the accumulative (in a sense, evolutionary) characteristic that learning to solve problems implies -the very idea that “learning by solving” seeks to convey-. The accumulative nature of solving problem capabilities has been forcefully put forwards by Nelson and Winter:

In many technological histories the new is not just better than the old; in some sense the new evolves out of the old. One explanation for this is that the output of today’s searches is not merely a new technology, but also enhances knowledge and forms the basis of new building blocks to be used tomorrow (255, 256).

The result of today’s searches is both a successful new technology and a natural starting place for the searches of tomorrow (257).

“Enhanced knowledge, new building blocks to be used tomorrow, natural starting places for the searches of tomorrow”: all these are potential features. If there is a “technological tomorrow”, then society at large and particular firms involved in serious problem solving searching would have at hand new insights to go further. Developed societies can mostly be sure of that, but what if the arrival of a “technological tomorrow” is highly uncertain? In underdeveloped landscapes it is not realistic to give for granted that solving problems activities that could lead to innovations and to accumulative learning are as natural as breathing. In fact, to routinely perform solving problems activities is bounded to have a steady flow of opportunities to solve non-trivial problems, that is, learning opportunities. We can understand the latter as situations in which different actors are able to strength their capacities to learn while interacting in the search for the solution of a given problem; thus, we may call them “ interactive learning spaces”(Arocena and Sutz, 2000). Learning by solving is precisely what happens in those places; its scarcity and fragility in developing countries is one of the reasons why accumulative learning is so difficult to achieve.

The ways to open opportunities for learning by solving are manifold. Many of them are located at the micro level, in the firms themselves, being related to concrete decision making and also with the style of decision making. However, how far micro experiences of learning by solving can go -how cumulative these experiences can be- depends on macro issues, also manifold, being one of particular importance the “style” of the development process.

“Style” is not a very precise term and can denote a variegated set of meanings. We shall concentrate here on how the relations with the newest technologies are usually perceived. Microelectronics, for instance, has been acknowledged almost everywhere to be a technological must, without which international isolation and productive backwardness are an unavoidable outcome. This broad consensus hides, however, quite different approaches to policy, stemming partly from different ways of evaluating national technological capabilities and from different ways of appreciating the importance of enhancing such capabilities. Very roughly, three different types of macro approaches can be mentioned: no effort to build a national electronic industry; efforts directed to be able to export products from a national electronic industry; efforts directed to build an electronic industry able to support the modernisation of other national industries and so to support, though indirectly, the export performance. The first approach is overwhelmingly present in small and medium developing countries; the second one has been the mark

of Japan and the Asian tigers, particularly of Korea; the third one seems to be the case of the Nordic countries, particularly of Finland (Lemola and Lovio, 1988).

From the learning by solving perspective, the first approach is poor in opportunities to learn. Imports are almost the only way to get in touch with technological agents of modernisation, which increasingly include, besides electronics, products and services originated in the life sciences; thus, it is difficult to assess adequately the own needs and the corresponding best solutions. The identification of the former and the implementation of the latter are usually provided by supplier's advice; consequently, the speed and scope of technological change tend to be divorced from national capabilities, and so virtuous circles of accumulative learning hardly develop.

Often, the reasons for taking this approach are not the absence of local capabilities. As Hirschman's approach suggests, the problem is related to the inability of using for development tasks existent capabilities that for some reason are hidden or remain "socially invisible". An important question regarding development in the globalised knowledge economy is why national capabilities to cope with complex problems, both in the entrepreneurial as well as in the academic arena, are not visualised as agents in development policies. One possible answer is again related with the BLAST/GALA dichotomy. The BLAST approach to the blend of development and new technologies would include, first, the goal of rapidly and radically transforming the traditional producing and exporting structure and, second, the dismissal of the local efforts to build own producing capabilities if this goal is not attainable. If you cannot become a strong exporter of new technologies then do not waste time and money caring for the consolidation of a local industry. The GALA approach to that issue would focus instead on the capacity of a knowledge-based local industry to foster a rational modernisation of traditional industries, something of the sort of let them "get by with a little help from their friends". This is the type of approach followed, at least for some time, in some of the Nordic countries. "In a small country such as Finland the question is rather of renewing the old production structure and production processes with the aid of electronics than replacing them with electronics. The indirect importance of the electronic industry may even be greater than its direct importance" (Lemola and Lovio, 1988: 154). The Finish example clearly relates this path with the enhancement of the opportunities for learning by solving and of accumulating knowledge and experience by user-producer interactions.

Enhancing learning by solving capabilities is clearly an expectable outcome of many of the innovation policies actually in place in the majority of OECD countries. They seem so suited for that purpose that the temptation of "policy transfer" is high when adopting a developmental point of view. Nevertheless, it must be remembered that the same rules may lead to divergent outcomes in societies with different institutional arrangements (North, 1990, p.101). In any case, beyond the specificity of each situation, a common issue can be discerned: learning by solving cannot be enhanced unless an actors-centred perspective is adopted. This is perhaps why it has been so hard to foster them in developing countries.

2.4 Some Latin American examples

The importance of having opportunities to accumulate solving-problems capabilities for innovative behaviour in developing countries can be exemplified with an Uruguayan example. The story goes as follows: in the mid-seventies, the state-owned telecommunication enterprise undertook a project to upgrade and enlarge the related infrastructure. The project had strategic importance, for the weakness of the telex infrastructure added to the expensive rates of telephone communication at that time were jeopardising the goal of opening the economy. The decided strategy was to enhance the telex infrastructure through new commutation nodes able to hold new lines. The two worldly available alternatives for so doing had flaws. The one that was adequate in terms of size relied on electro-mechanical technology, obsolete by that time; the one adequate in terms of technology, for it relied on digital circuits, was simply enormous for the size of the country, surpassing the demand projected ten years ahead. The state-owned enterprise took a singular decision in the Uruguayan tradition: it launched an international bid to fulfil precisely the detected need –commutation nodes based on digital technology, small in size and with modular possibilities to grow- and allowed local firms to participate in the bid. Two by then recently formed electronic firms, owned by university professors fired from faculty after the military take-over in 1973, won the bid and started working. They needed to use their "capacity to

innovate in scarcity conditions”, for the micro-electronic device that was the core of the technical part of the bid was suddenly out of reach: the firm that produced it was also in the bid and was turned down. The story was a technological success: small commutations nodes for 124 lines were designed, produced, installed and operated; besides, they were added to the net each time the demand for telex lines reached the roof of the available infrastructure. During that process, the basic design was changed to allow for the use of front runner technology, like the new 32-bits microprocessors.

To assess the weight of the associated process of learning by solving undergone by those firms, it is useful to follow the story a bit further: what happens when in the early eighties a big innovation, the fax facility, reduced drastically the telex demand? The local firm and the telecommunication enterprise made an agreement to shift the last telex contract into a new technological challenge: to design and produce the first package commutation network to allow data transmission through computers. Technological success was present also in this even more uncertain and complex experiment. The accumulative nature of the learning process undergone by the firms is pretty clear: they learned about core technologies, about design, about running complex process in time, about negotiating with suppliers and also about diversifying sources for strategic inputs. No less important, they learned to establish a trustworthy relation with the “user-side” of the project. Moreover, they learned all this by solving all type of problems all the time.

What could have happened if this path of specialisation –updated telecommunication infrastructure of small and modular design- had continued, that is, if the learning by solving process had continued? To answer that question, a new opportunity to learn must be identified. It came in the mid-eighties with the digitalisation process of telephone exchanges. This was a far more complex task than the former: probably no local technological forces could have addressed it without international participation. However, with the solving-problems capabilities acquired during the preceding stages the local electronic firms would have been good partners in an international venture. But this was not the official choice: the digitalisation of telephone exchanges was bought turnkey to a foreign provider without any participation of “local knowledge”. This outcome deserves two considerations. First: is there any example of a different path followed by a developing country, related to this very same technology at approximately the same time? This example exists indeed and it is that of Korea. In 1981, the Korean government decided to change the telephone system into a digital one, by taking the following steps: i) a consortium of four Korean firms associated with foreign firms started to produce locally under foreign design and with foreign supplies (with time, the local content of the produced equipment rose, reaching 76% of the total); ii) a public R&D institute launched a joint-venture with these four firms to develop a telephone exchange system for rural telecommunication based on the same technological principles; iii) once the design completed, it entered into production and by 1987 replaced the imported systems; iv) the local consortium introduced several improvements to the original design and started exports; v) a project was launched to develop a similar system with higher density for urban use (Kim, 1993, p. 22).

The second consideration has to do with the follow-up: what happened with the Uruguayan electronic industry after the decision that left her aside? The telecommunication part of the industry virtually disappeared. The industry as such continued, accumulating knowledge differently, that is, not so much through concentration on a specialised range of products but by solving problems of other industries, in a “tailor-made” style. Nobody can know what would have happened if the accumulation in digital telecommunication small switching systems could have continued: perhaps it would have been impossible to cope with the frantic rhythm of technical change and the gigantic R&D and marketing spending of the leader firms; perhaps interstitial niches of exports could have been founded, allowing the development of a new pattern of specialisation. Besides speculations, the fact is that the learning by solving process in digital telecommunication came near to a halt.

This story is far from being unique, at least in Latin America. The Argentinean and the Brazilian “computer industry stories” have many points in common with the one just told. Brazil developed a fairly important computer industry during the late seventies and eighties, one of which most remarkable features was the high proportion of technical staff in the R&D departments of the local firms. The learning by solving accumulation begin to reverse once the informatic industry was “opened” in the way it was. The consequences in terms of the narrowing of learning by solving opportunities were large: recent empirical research shows that during the first half of the nineties, overall employment in ICT was cut by half and graduate personnel in particular fell from 22.000 to 13.000 from 1989 to 1992. “Besides this decrease in the total number of qualified personnel, some of the engineers which were engaged in R&D activities

were transferred to other activities, such as marketing, production, sales and technical assistance." (Cassiolato, 2000) Evidence has also been found in Brazil that skilled people in ICT areas are migrating to the USA, where employment prospects in the fast-growing ICT sector are very high. Squeezed between the lost of local opportunities to develop creative work in the computer industry and the brain drain phenomenon, learning by solving in that branch is in progressive decay.

The Argentinean story is remarkably similar. In Argentina, in the early seventies, a project to develop a minicomputer -hardware and software- was undertaken, as a branch of a factory of rubber wheels, named FATE. It was an ambitious project indeed, in scientific and technological terms as well as in socio-political terms. It gathered some of the most talented young Argentinean scientist and engineers and during its short but intensive life, a fair amount of learning was developed. A complicated mixture of pressures by multinationals and local political decisions, the latter issued from the military upheaval in the mid-seventies, put an end to the experience. A book analysing this experience as well as the Brazilian one, alluding to a well known song of the sixties, addresses in the following way the question of loosing acquired capabilities: "Interviewees were asked what happened to the knowledge and experience generated within FATE: *where have all the scientist gone?* 'Gone to IBM and other multinationals, every one' was the response, and implicit in this answer was the question, when will they ever learn, when will they ever learn?" (Adler, 1987: 237).

All these stories have particular flavours, but the reasons why the learning by solving accumulation came to a relative halt are more general, pointing to the heart of the difficulties faced by underdeveloped nations in overcoming their laggard position in the knowledge based and innovation driven global economy.

Concluding remark

As stressed by the quotation from Nelson and Winter which opens this paper, disparities in development and strains in backward societies are among the fundamental traits of our world. They are closely related to the new role of knowledge and to the frantic rhythm of innovation, which are generating the "learning divides" that characterise the problem of underdevelopment nowadays. As we have tried to show here, it stems from the evolutionist approach that promoting the multiple social activities related with "learning by solving" is a key issue for development.

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References

- Adler, E. (1987): *The Power of Ideology. The Quest for Technological Autonomy in Argentina and Brazil*, University of California Press, Berkeley.
- Arocena, R. and Sutz, J. (2000): "Interactive Learning Spaces and Development Policies in Latin America", DRUID Working Paper 13/2000, Dec. 2000.
- Cassiolato, E. (2000): "National Systems of innovation on the South", paper presented to the South-South-South Workshop, 20-23 May, University of Western Sydney, Sydney.
- Clark, N. and Juma, C. (1988): "Evolutionary theories in economic thought", in Dosi *et al*, edits., pp. 197,218.
- Dalum, B., Johnson, B. and Lundvall, B.A. (1992): "Public Policy in the Learning Society", in Lunvall, editor, pp. 296, 317.
- Dasgupta, S. (1996): *Technology and Creativity*, Oxford University Press, N.Y.
- Dosi, G., Freeman, C., Nelson, R., Silverberg, G. and Soete, L. edits.(1988): *Technical Change and Economic Theory*, Pinter, London.
- Edquist, C. editor. (1997): *Systems of Innovation. Technologies, Institutions and Innovations*, Pinter, Londres.
- Freeman, C. (1992): "Science and economy at the national level", in Freeman, C., editor. *The Economics of Hope*, Pinter, London, pp. 31, 49.
- Freeman, C. (1987): *Technology Policy and Economic Performance. Lessons from Japan*, Pinter, Londres.
- Hirschman, Albert (1958): *The Strategy of Economic Development*, Yale University Press, New Haven.
- Hirschman, Albert (1981): *Essays in Trespassing. Economics to Politics and Beyond*, Cambridge Univ. Press, Cambridge.
- Hirschman, Albert (1986): *Rivals views of market society and other recent essays*, Elisabeth Sifton Books - Viking, New York.
- Johnson, B. & Lundvall, B-A. (2000): "Promoting Innovation Systems as a Response to the Globalising Learning Economy", paper for the Seminary "Arranjos e Sistemas Produtivos Locais e as Novas Políticas de Desenvolvimento Industrial e Tecnológico", Rio de Janeiro.
- Kim, Linsu (1993): "The evolving role of the R&D community in industrialization: the Korean experience", presented in the Workshop of Experts on the Promotion of Interlinkages Between the Research Community and the Enterprise Sector", Buenos Aires, March.
- Lemola, T. and Lovio, R. (1988): "Possibilities for a small country in high-technology production: the electronic industry in Finland", in Freeman, C. and Lundval, B.-A. edits. *Small Countries Facing Technological Revolution*, Pinter, London, pp. 139, 155.
- Lundvall, B.A. (1985): "Product innovation and user-producer interaction", Industrial Development Research Series, Nº 31, Aalborg University Press, Aalborg.
- Lundvall, B.A. (1988): "Innovation as an interactive process: from user-producern interactions to the national system of innovation", in Dosi *et al*, edits. pp. 349, 369.
- Lundvall, B. A editor. (1992): *National Systems of Innovation - Toward a Theory of Innovation and Interactive Learning*, Pinter Publishers, Londres.
- Meier, Gerald M. (1976): *Leading Issues in Economic Development*, Oxford University Press, New York.
- Nelson, Richard R. and Winter, Sidney G. (1982): *An Evolutionary Theory of Economic Change*, Belknap, Harvard.
- Nelson, R.R., ed. (1993): *National Innovation Systems. A Comparative Analysis*, Oxford Univ. Press, N. York.
- North, Douglass (1990): *Institutions, Institutional Change and Economic Performance*, Cambridge University Press.
- Pisani, E. (1984): *La main et l'outil. Le développement du Tiers-Monde et l'Europe*, Robert Laffont, Paris.
- Sen, Amartya (1984): *Resources, Values and Development*, Harvard Univ. Press, Cambridge, Ma.
- Sen, Amartya (1997): "Development Thinking at the Beginning of the XXI Century", in Emmerij, L. edits. *Economic and Social Development into the XXI Century*, Interamerican-Development Bank, Washington.
- Sen, Amartya (1995): *Inequality reexamined*, Harvard Univ. Press, Cambridge, Ma.
- Sen, Amartya (2000): *Development as Freedom*, Anchor Books, N. York.
- von Hippel, E (1988): *The Sources of Innovation*, Oxford University Press, N.Y.
- Weizenbaum, J. (1976): *Computer Power and Human Reason. From Judgement to Calculation*, Freeman and Co., San Francisco.