The First Globelics Conference:
Innovation Systems and Development Strategies for the Third Millenium

Theme A: National innovation systems and economic development
* National Systems of Innovation: old and new perspectives

Understanding underdevelopment today: new perspectives on NSI

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Introduction

One of the aims that define GLOBELICS is to connect more profoundly NSI and underdevelopment. "It is well known that applying a theoretical framework outside the arena where it was first developed may bring fundamental new theoretical insights", states the Presentation of the First Globelics Conference. Applying NSI conceptualization to underdevelopment –or looking into underdevelopment from the NSI point of view- will probably need to include new perspectives in the theoretical framework; perhaps it may also bring some new insights.

Main features of underdevelopment are not static. Even if important economic and social aspects of underdevelopment are as notorious today as they were yesterday, the actual drivers of the situation will most certainly be different than those of the past. Two fundamental changes, strongly intertwined, shape underdevelopment at present: the process of globalization and the renewed dividing power of knowledge. The last sharpens the social divide between those able to learn and to work in a learning environment, and those marginalized from one of the main sources of self-reliance and self-esteem of these days.

Now, underdevelopment has long ago been acknowledged as not being merely an interim situation in the road to development; convergence towards the basic elements that constitute whatever we may call a "development situation" is not certain. Specifically, it is not evident that NSIs exist in underdeveloped countries. The concept, that holds well empirically in the North, is the way to name, ex-post, an existing situation, while in the South it is rather an ex-ante way of describing a desired yet not fully real situation (Arocena and Sutz, 2000a). More generally, innovation and learning processes in the South have specific traits; in fact, that is today one of the main distinctive characteristics of the "peripheral condition", on which Latin American scholars of development focused yesterday their attention.

In the first part of this paper we elaborate on the assertions of the last two paragraphs. In particular, we try to highlight some issues that should be taken onboard when reflecting around NISs and underdevelopment. Then we turn to a very preliminary and tentative formulation of some issues that may suggest new perspectives for NSI as a research program, particularly, even if not exclusively, in connection with the search for new strategies for development.

I. On the underdeveloped condition

Knowledge is the great destabilizing force of our time:

"The central phenomenon of the modern age is that as an aggregate we know more. New knowledge developed in the past three centuries has created a great deal of social conflict and suffering, just as it was the origin of undreamed-of wealth and security. It revolutionized the structures of firms and households, it altered

the way people look and feel, how long they live, how many children they have, and how they spend their time. Every aspect of our material existence has been altered by our new knowledge." (Mokyr, 2002:2)

The destabilization power of knowledge affects social relations and habits, enlarging benefits and opportunities as well as risks and damages. But that happens in a very asymmetric way, so knowledge is nowadays a key factor of inequality between human beings, and particularly of one of the most salient manifestations of inequality, that is, underdevelopment.

(I.a) Learning prospects and underdevelopment

The learning prospects of any social agent depend on the capacity and the opportunities he has had so far to acquire knowledge, as well as on the opportunities to enhance the acquired knowledge by using it creatively and by further accumulation. These two types of situations are rooted in quite distinct social processes and institutions. The first one has mainly to do with access to education and training and with the specific institutions devoted to these aims. The second one is chiefly associated to the social demand for knowledge, where production and all the related institutional setting play a paramount role.

Development trajectories are strongly related to learning prospects, particularly so in the current globalized knowledge economy. Learning prospects, we shall argue, are influenced by the setting and evolution of systems of innovation at local, national or regional level. So, from a developmental point of view, the possible interactions between learning prospects and systems of innovation deserve special attention.

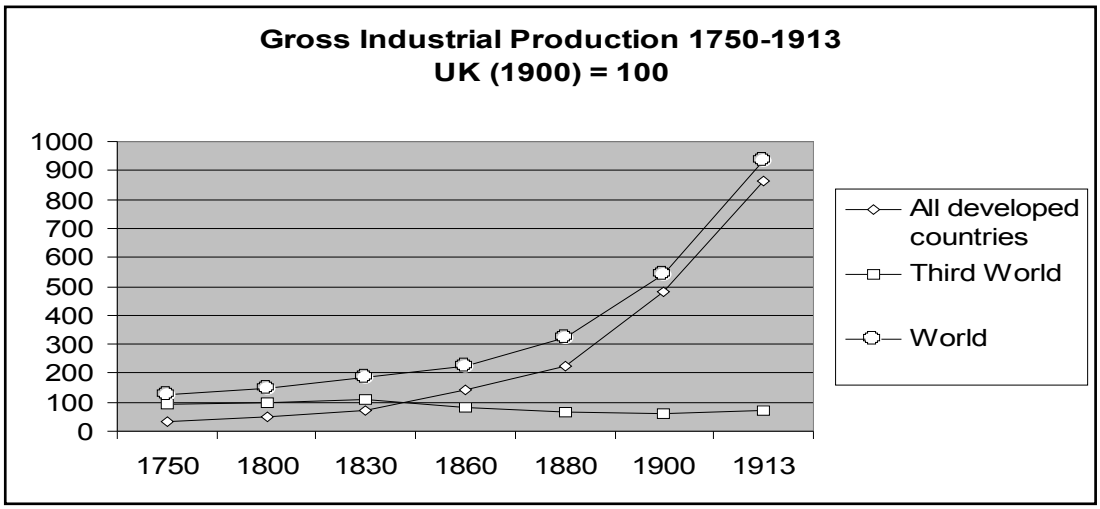
French scholars use to say that a good prospective must start by a good retrospective. Concerning underdevelopment and learning, the following table can be useful for such a retrospect.

Table 1.- Gross volume of national industrial production 1750-1913 (U.K. in 1900 =100)

	1750	1800	1830	1860	1880	1900	1913
All developed countries	34 d	47	73	143	223	481	863
France	5	6	10	18	25	37	57
Germany	4	5	7	11	27	71	138
U.K.	2	6	18	45	73	100	127
United States		1	5	16	47	128	298
Third World	93	99	112	83	67	60	70
China	42	49	55	44	40	34	33
World	127	147	184	226	320	541	933

Source: Bairoch 1982, table 8, quoted in (Mann 1993: 262)

The figures –however tentative they might be- allow to suggest that during the second half of the XIX Century, in some places of the world, a big increase in the social demand for knowledge took place, associated with the rise of industrial production. At the same time, the sharp decline in the global industrial production share of the Third World suggests that an inverse movement took place there. This is not to say that the industrial production of the Third World was at any time a strong knowledge demander; it means simply that once the industrial dynamism became concentrated outside those countries, the social demand for knowledge became structurally weak there. This can be clearly be seen in the following graphic, based on the above table.



Learning prospects began to diverge since then. In "all developed countries" a wealth of teaching and training institutions flourished , and research became a profession cultivated in universities, assuring the social reproduction of a specialized intellectual working force. In particular, engineering understood as an academic discipline was the mark of the United States "translation" of the German XIX Century innovation of the research university: the "wedding of science with the useful arts" that took place there included the early integration of academic science with the practical orientation of teaching and research in engineering (Ben-David, 1983; Noble, 1977). In the "Third World", universities also flourished. The overall unbalance in terms of the production of new knowledge is, however, striking.

Table 2.- Participation of three conglomerates in general indicators and in R&D indicators (1997)

	% of World GDP	% of World population	% World R&D expenditure	% World number of researchers
Developed countries	61.1	22.3	84.4	71.6
Developing countries	38.9	77.7	15.6	28.4
Latin America	9.2	8.9	3.1	6.7

Source: Based on Unesco, 2001

Table 3.- Some indicators of S&T by region (1997)

	Researchers per million inhabitants	GERD by researcher FTE* and **	R&D spending as % of GDP	GERD per capita of total population ***
Developed countries	3033	124	2,2	377
World	946	105	1,6	100
Developing countries	347	58	0,6	20
Latin America	715	48	0,5	34

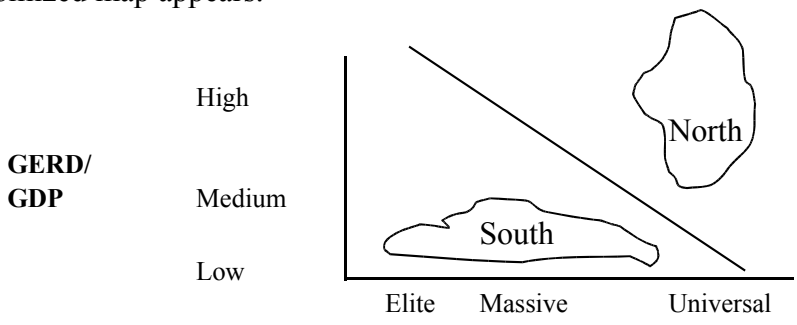
* FTE: full-time equivalent; ** thousand of PPP dollars (purchasing power parity); *** PPP dollars.
Source: Based on Unesco, 2001.

In terms of learning prospects, access to higher education is an important indicator. All the developed countries, including the NICs, have already reached the threshold of what is conceptualized as "universal access", that is, at least 35% of all the cohort of age between 18 and 24 years going into higher education. Of all developing countries, only Argentina has reached this threshold so far. Two huge countries like India and Brazil continue to have "elite access", with less than 15% of their youngsters going into higher education.

The learning situations reflected by the above shown indicators do not grow out of a vacuum. The developed world growing demand for knowledgeable people, inside and outside national borders, is the outcome of a "knowledge based and innovation driven" evolving economy (de la Mothe and Paquet, 1998). The poor and stagnated learning situation of the "South" is not only the result of long range social inequality plus myopic policy views about the role of higher education in development. It stems also from the lack of sustained, inward oriented, knowledge demand coming from production.

In another paper (Arocena and Sutz, 2000b), we have argued that the loci where knowledge is used and produced with the aim of solving problems, leading eventually to innovations, are the "interactive learning spaces", spread all over society. Interactive learning places can be highly institutionalized within organizations, or they can be ad-hoc arrangements dissolved once their goal has been achieved. The main point is that they provide the "space" where different actors are able to strength their capacities to learn while interacting in the search for the solution to a given problem. Interactive learning places can be seen, then, as a synthesis between knowledge capabilities already acquired, and opportunities to apply them creatively and to go on learning and accumulating knowledge while interacting in problem-solving activities.

This concept helps to focus on the opportunities side of the learning situations, something that is usually taken for granted in the "North". There, encounters are relatively fluid between those that need knowledge to solve some kind of problems and those able to interact with them in order to recognize the useful existing knowledge, to detect the missing knowledge needed, to organize the search process to acquire it and, finally, to help to integrate the new knowledge into the previous base and the whole into current practices. We can say that the North is "interactive learning spaces rich". These type of encounters are not at all fluid in the South. This is so not only because of the relative scarcity of capabilities, but mainly because of the severe scarcity of opportunities to put them at work. We can say, then, that the South is "interactive learning spaces poor". If we approach quantitatively the richness in interactive learning places of a country by its position in a pair of Cartesian axes where the abscises measure the access to higher education –universal, massive or elite- and the ordinates approximate opportunities to apply knowledge creatively by GERD/GDP, a clearly dichotomized map appears.



The divide between North and South sketched in the upper figure can be termed as a "learning divide" (Arocena and Sutz, 2000b). Underdevelopment today can be conceptualized as being in the lower part of the learning divide and having severe difficulties to cross the line. Here "South" refers to whole societies: in individual terms, as it is rather obvious, there are people under the line in interactive learning spaces rich societies and people above the line in interactive learning spaces poor societies.

For societies as a whole, crossing the line implies traveling along the abscises axis away from a situation in which only a tiny proportion of the population is able to reach higher education. It implies also moving upside along the map to situations where the opportunities to apply knowledge are significantly clustered. A first assertion is that the latter is far more difficult than the former; a second one is that the latter is intimately related with the "state" and possible evolution of the local or national systems of innovation.

Albert Hirschman used to describe underdevelopment as a situation in which decision-makers are unable to put to work for development purposes the strengths that exist in a given society. Underdevelopment is characterized by a low absorption of available high-level trained people by the productive structure[1]; it is also characterized by an overwhelming outward oriented science and technology demand. Both situations are technological expressions of the inability to put available capabilities to work for development purposes. This is why the lack of opportunities is even more damaging than the weakness of capabilities: even the capabilities that exist tend to vanish if they are not used.

We can sum-up by re-creating a statement made in a recent paper by Lundvall et al.[2] One of the reasons that explain the weak economic performance of underdeveloped countries is the scarcity of interactive learning places, where social capital can grow by allowing people to learn, collaborate and trade. One of the most dangerous consequences of this situation is the growing polarization and exclusion suffered by interactive learning spaces poor societies, those that are under the learning divide. To allow them to have a stronger learning capability and access to the networks where learning takes place is crucial for self-sustainable development.

Consequently, learning prospects deserve high priority when addressing underdevelopment. These prospects depend on the social ability to promote capabilities and opportunities to learn of a variety of social actors. "Analysis" can, perhaps, be of some help for this matter, following the meaning given to the term by Nelson and Winter (1982: 379): "… the inquiry of professionals trained in social sciences or in other disciplines into the policy alternatives, the values at stake, the likely consequences of adopting different policies, and the articulation of the findings of such an inquiry with the express aim of illuminating and influencing policy choices." One of the reasons why the NISs approach seems so useful for thinking about development in general and learning prospects in particular, is precisely the consistent yet flexible framework it provides for analysis. The flexibility of NISs approach implies the possibility, when analyzing different realities, of making different emphasis, of looking into different aspects or even to make different assumptions about some issues, without loosing consistency. In the next section we shall try to profit from this flexibility to address the challenge of "applying a theoretical framework outside the arena where it was first developed"; we shall do that bearing in mind the issue of learning prospects.

(I.b) Innovation as seen from the South

In the Presentation of the First Globelics Conference it is said that: "Behind the effort lies the assumption that further insights in how innovation and competence building takes place in less developed countries help to stimulate a renewal of development strategies and

[1] For all Latin American countries where figures are available, less than 30% of all science and technology trained personnel work in industry; most of them work at universities and governmental organizations. The situation in most developed countries is the exact reversal of this one.

[2] "The only way to explain the strong economic performance of Denmark and other small economies with a weak specialization in high technology products it to take into account the social capital that makes it easier for people to learn, collaborate and trade. The most important threat to this mode of production and innovation is the growing polarization and exclusion of those who do not fit into the learning economy. To give those a stronger learning capability and access to the networks where learning takes place is crucial for the sustainability of the learning economy." (2002: 219)

thereby has a real impact in stimulating development." In other words, this is to accept that "the ability of a theory to illuminate policy issues ought to be a criterion by which to judge its merit" (Nelson and Winter, 1982: 372). We shall briefly present here some perspectives, suggested by the "underdeveloped condition", that can illuminate policy issues related with NISs and competence building.

The non-systemic behavior of innovation and diffusion in underdevelopment

NISs are centrally concerned with institutions related in a way or another with innovation. The approach is particularly concerned with existing institutions of this sort. However, the approach has been less focused on situations characterized by the lack of institutions, or by institutions unable, for different reasons, to perform well from an innovation point of view.

The institutional fabric related to innovation, particularly its relational density, plays an important role in the strengthening of interactive learning places. This has been well understood in highly industrialized countries as well as in newly industrialized ones, where a great diversity of policy instruments and organizations have been devised to favor encounters for innovation. In underdevelopment, organizations without real knowledge of what innovation means in a given productive milieu, with ambitious and fuzzy goals, badly financed and without experienced and committed personnel, constitute often the formal institutional setting for technology policy. On the other side, the real policy, the decision-making processes that have concrete learning and innovation consequences, occur in scattered organizations, often as by-products of policies oriented to other goals, without much care about its positive or negative impacts on innovation, and without formalized instances to discuss them. These situations are not exclusively present in the South; there, however, they often represent main trends.

The principal consequence of that state of affairs is that actors of innovation are left to their own initiatives to start relationships. User-producer interactions occur, but slowly, without much possibilities to display "demonstration effects", often too weak to accomplish completely their goals, even more often "encapsulated" in their first interaction and without further diffusion. This means that the cost of organizing interactive learning places is high, the probability of their appearance is weak, as well as their capability to give rise of virtuous circles, like those described by Malerba (1993) in the Italian case, for instance.

The question is: how can we use the NISs approach to figure out policies aimed at competence building in situations like these? When a system does not exist as such, looking at the whole does not give a clue to understand how the different parts interact. However, even if "systems" are not present, actors of innovation will certainly exist; the emphasis of the NISs approach on actors and their interactions suggests a bottom-up strategy to understand innovation dynamic in such situations. It starts by identifying interactive learning places; it follows by analyzing the factors that led to their appearance and, eventually, those that hamper their development into more systemic networks. Then it examines what would be needed to make less hazardous the former and to overcome, at least partially, the later. In doing this the focus is not on institutions, but on actions.[3]

In the same way that we should not assume that institutions work in a system-like manner in underdevelopment, we should neither assume that diffusion processes work properly there. Many reasons suggest that it is important not to consider innovation and diffusion as one and the same process. Among those reasons, a relevant one is that frequently innovations do not spread more or less spontaneously; moreover, very often we find examples of truncated diffusion processes, meaning that an efficient innovation is effectively introduced in some context but its diffusion does not take place or is much

[3] A very good example of the results attained in the analysis of innovation dynamics in non-systemic endeavors is the work done by RedeSist studying local innovation arrangements in Brazil.

delayed. This phenomenon has been observed long ago; as a telling example, Rogers (1995: 7) describe the incredibly long and costly process of adoption by the Royal Navy of a very simple way of preventing scurvy. Nowadays, the frequent truncation of diffusion processes can be seen as a relevant trait of innovation in underdevelopment.

The last assertion seems important both for research and for policy making. The NISs approach, with its emphasis on interactive learning, and the idea of innovation as a socially distributed process (von Hippel, 1988), sketch a bottom-up perspective for these issues. Diffusion of innovation often depends on the interactions of several actors, with quite different resources and cultures. Thus, studying specific cases of truncated diffusion may offer interesting insights about the performance of an innovation system; in particular, it may be useful to gauge the more or less systemic functioning of the set of organizations and collective actors potentially related with innovation processes.

Often innovation policies focus on the introduction in a given context of new ways of solving problems, implicitly assuming that efficient innovations will find, sooner rather than later, their way to spread. That may be the rule where innovation and technical change have been integrated since long ago to the normal functioning of the economy, and are widely seen as main clues of prosperity. But where such is not the case, the dynamics of diffusion can be very different.

Diffusion deserves special attention in strategies that do not focus on the high-tech sectors but aim to upgrade the knowledge and learning contents of all practices, notably those related with traditional economic activities, which in the South involve the overwhelming majority of the population. From this point of view it is worthwhile to stress that diffusion should not be seen as an unilateral transference from those who know to those who do not know. "Recognition of the existence of re-invention brings into focus a different view of adoption behavior: Instead of simply accepting or rejecting a innovation as a fixed idea, potential adopters on many occasions are active participants in the adoption and diffusion process, struggling to give their unique meaning to the innovation as it is applied in their local context. Adoption of an innovation is thus a process of social construction." (Rogers, 1995: 179) In short, diffusion is potentially a major source of interactive learning.

There are no models for National Systems of Innovation, but…

When national systems of innovation do not properly exist, there might be a strong temptation to adopt a model and declare the will to build it. NISs approach strongly discourage the idea of "a" model for the systemic behavior of innovation (Edquist, 1997). In the same vein, Nelson and Winter declare to "have trouble with the idea that analysis helps to identify a 'best' policy", in particular because this idea implies the construction of a model within which a best policy could be found; models, they recall, are highly simplified and often misleading characterization of the real context (1982: 381). However, one thing is to reject the idea of "models" of NISs that should serve as institutional benchmarking regardless the context, and quite another is to fail to recognize that there are some features of NISs intimately related with social goals that are extremely important everywhere.

As already noted, the strong performance of some small economies without a strong specialization in high technology is directly related by Lundvall et al (2002) to social capital. So this connection should deserve great attention in the South. Social capital "refers to features of social organization, such as trust, norms, and networks, that can improve the efficiency of society by facilitating coordinated actions" (Putnam, 1993: 167). "Stocks of social capital (…) tend to be self-reinforcing and cumulative."; conversely, the scarcity of these stocks tend to vicious circles that also are self-reinforcing (Putnam, 1993: 177).

In some societies it can be said that a NIS "works properly" because pre-existent social capital is high; it is perhaps not unsafe to guess that one of the reasons why the institutional setting of those NISs is particularly efficient in promoting innovation is that it is

inspired in society itself. In underdevelopment this is not the case and so the institutional setting of NISs needs to be more normative. This is not a question of benchmarking but of inspiration. It can be said that NISs in underdevelopment should be inspired by the aim of enhancing social capital as a way to facilitate coordinated actions, at all levels. This will lead, in the realm of innovation, to system-like behavior.

From and innovation perspective, the enhancement of social capital occurs where people build mutual trust and understanding in the process of solving problems and diffusing the found solutions; this is a way to refer, again, to interactive learning places. The normative orientation of NISs in underdevelopment implies to pay special attention to the protection and strengthening of such places, and to the articulation of isolated actors to help new ones to appear. For being able to do that, careful "bottom-up" analysis must be carried out. This is so because the lack of social capital implies that "top" generic designs will probably loose energy and fitness in their way "down". The challenge is to learn from society where and how the enhancement of social capital has occurred around innovation efforts, to better understand the reasons behind those behaviors.

A very important conceptual and empirical contributions in this direction stem from a large research project organized by the Brazilian research network RedeSist. Stemming from 26 case studies analyzed up to now in different regions of Brazil, Argentina and Uruguay, covering industries such as aerospace, biotechnology, automobile, textiles-clothing, wine and leather-footwear, the concept of *local productive systems and arrangements* was developed.

"We define a *local productive system* as any productive agglomeration involving economic, political and social agents localized in the same area, performing related economic activities and presenting consistent articulation, interaction, co-operation and learning processes. It includes not only firms (producers of final goods and services, suppliers of inputs and equipment, service providers, etc.) and their different forms of representation and association, but also other public and private institutions and organizations specialized in educating and training human resources, R&D, engineering, promotion, financing, etc. We have also developed the concept of *local productive arrangements* to include productive agglomerations in which there is no (or almost no) articulation among the agents." (Lastres and Cassiolato, 2003: 9)[4]

This approach and its empirical findings may allow a diachronic analysis of the degree of articulation, and, in particular, a study of how and if "arrangements" tend to become "systems" - or if the contrary happens, as it is often the case in underdevelopment-, and why. We can summarize the idea of "normative inspiration" for NISs by saying that whatever their shape, they ought to help arrangements to become systems, as a way to enhance both innovation and social capital.

Underdevelopment and conflicts

In an evaluation of a Research Project focused on the countries of Central America, where the NSI framework is used, it is stated:

"[…] the most important weakness of the system of innovation approach, at least when applied to developing countries, is probably that it lacks an adequate treatment of the political and power aspects of development. (…) The close relations between power and knowledge has been emphasized by Foucault and it seems necessary to take these relations onboard when analyzing innovation systems in developing countries." (Johnson and Segura-Bonilla, 2001: 11)

As the authors go on saying, interactive learning and innovation are not necessarily a purely positive sum game. This is true everywhere and has been explicitly acknowledged long ago: Schumpeter's hurricanes of creative destruction imply that in many cases while some actors will gain with innovation, others will loose. In underdevelopment, though, more

[4] For a more detailed account of these issues see Cassiolato, J., Lastres, H. & Maciel,M. eds. (2003).

than creative destruction we usually find destructive creation. Destructive creation has many expressions. One of them occurs when something new is introduced in a given society without making use of its accumulated competence. This means that opportunities to learn that could otherwise have been opened are not open; this can also mean that existing interactive learning spaces come to a close.

Coming back to power and its association with knowledge, it is worthwhile recalling Foucault's approach: "Power must be analyzed as something that circulates, something that only works chain-like. It is never localized here or there, it is never in the hands of someone, because it is not an attribute like wealth or a good. Power functions, and is exerted, through networked organizations." (Foucault, 1979:144, our translation from Spanish) Conflicts involving power related to knowledge and innovation occur at all levels, from the setting of the research agenda to governmental technology purchases. Power is not concentrated in a single place or a single actor: this is in fact the reason why conflict looks so ubiquitous. National Systems of Innovation can be seen as a result of past and current conflicts around knowledge and innovation at all those levels, both within a given country and in its international relations.

Destructive creation as a main social trend in underdevelopment is, in part, the outcome of conflicts around the conceptualization of innovation and its role in development processes. In such conflicts, those who understand innovation as an interactive learning process, and consequently fight to open interactive learning places, have substantially less power than those concerned mainly with the question of access to the results of innovations already achieved somewhere. These conflicts can have different configurations and protagonists: workers and managers in private industries; small national high-tech firms and the boards of public enterprises; public decision-making bodies and international firms. NISs structures reflect this, both in what exists and what is missing, and in what is strong and what is weak. More generally, the analysis of NISs as shaped by conflicts in the knowledge/power dimension can illuminate the difficulties to articulate coherent actions to foster innovation and competence building in underdevelopment.

NISs and state action

In the concluding chapter of Nelson's book comparing NISs it is stated:

> "To some extent at least, a nation's innovation system is shaped by factors such as size and resource endowments that affect comparative advantage at a basic level. But it also is true that a nation's innovation system tends to reflect conscious decisions to develop and sustain economic strength in certain areas, that is, it builds and shapes comparative advantage." (Nelson, 1993: 508)

The state is one of the actors related to such conscious decisions. These are taken by state bodies, and are often formulated as public policies. However, between those decisions and the effective implementation of the public policies that should follow, we see the "institutional machinery, … that sometimes seems to take on a life of its own" (Nelson and Winter, 1982: 376). The importance of the civil servants and others who carry out a program or policy cannot be underestimated: "…the shape of a policy is to a considerable extent determined by how it is implemented" (ibid: 377). Moreover, "although by design bureaucracies may only implement policies, in actuality they shape them, too." (Rueschemeyer and Evans, 1985: 52).

Civil servants who carry out public policies on science, technology and innovation are part of the state. The specific knowledge they have, the type of experience that is valued when appointing them, the prestige associated with their tasks, are a reflection of the importance given to science, technology and innovation by the state. Theda Skocpol, talking in general terms about the resources the state have at its disposal to implement policies, asserts that some of them "come to be rooted in institutional relationships that are slow to

change and relatively impervious to short-term manipulations. For example, do state offices attract and retain career-oriented incumbents with a wide array of skills and keen motivations?" (Skocpol, 1985: 16). In underdevelopment, state offices devoted to science, technology and innovation, regardless where they are placed in the bureaucratic structure, are frequently not well equipped with permanent teams of well-trained people able to give legitimacy and visibility to whatever policies might have been outlined. Weak knowledgeable teams are usually unable to get a sound comprehension of innovation dynamics and problems –or to interact with other people for that purpose- which leads, in the first place, to difficulties to identify and get pertinent and analyzed information for decision making. Further on, once policies are defined, the implementation phase and the critical revision of what has been obtained is also limited in quality and scope by the weak specific capabilities of state teams.

This situation can be as powerful as other social fabric weaknesses in explaining difficulties and obstacles to put innovation at work for development purposes. The NISs approach has not gone too far in this direction of analysis. This is so, perhaps, as in other cases, because in developed countries there are no big problems to analyze in this regard. The economic and social importance of innovation has led to an evolutionary process where state offices for science, technology and innovation do attract and retain people able to play a helpful role in the setting and implementation of useful public policies. Of particular importance is the capability of these state teams to interact with academic milieus where science, technology and innovation are studied from all imaginable angles: as in other organizations, what "inside" people know is fundamental to gather and integrate knowledge produced outside. These situations are quite infrequent in underdevelopment.

Thus, competence building should include explicitly the public institutional bureaucratic machinery for science, technology and innovation policies. This involves issues that "are slow to change and relatively impervious to short-term manipulations". Quite a lot of innovativeness and determination is necessary to give the state this type of resources to enhance its NIS, but first of all the problem must be recognized as such.

We have barely outlined some perspectives that it seems useful to take onboard when reflecting on NISs from underdevelopment. More will probably emerge, as long as this theoretical approach continues to be applied to nations in the "South". It is worth to keep an eye on them, for two interrelated reasons. First, because they help to "tailor" the approach to situations far different from those that inspired it; second, because once thus tailored, the theory may deploy all its might for analysis and policy making, perhaps not only in underdevelopment.

II. Some problems and conjectures for a research program

"Old" perspectives on NSI are in fact quite new. After all, the first conceptualizations of the term were proposed in the mid-1980s (Lundvall, 1985; Freeman, 1987).

Nevertheless, such perspectives are already "classical". The NSI approach has helped to understand better the dynamics of innovation everywhere. Emphasis on actors and its interactions, on institutions and the articulations between them, and on the interrelated behavior of firms, knowledge producers and government, helped to visualize where to look for strengths and weaknesses in the innovative fabric. From the point of view of underdevelopment, the NISs theory is a particularly useful analytical tool because:

(i) It highlights the relevance of several social actors, thus going beyond the schematic opposition between state and market.

(ii) It focuses not only on economic matters but also on political, institutional and cultural issues.
(iii) It directs our attention to some concrete processes of interactions between actors and organizations, offering a general frame for their study.

Those three potentialities of the theory pave the way to a fourth and fundamental one:

(iv) It is a tool for studying the concrete aspects of innovation activities in underdeveloped countries, thus contributing to a revitalization of Development thinking and of one of its defining tasks, the global and interdisciplinary analysis of the specific features of "the peripheral condition". (Arocena and Sutz, 2002)

"New" perspectives on NISs can rise from quite different intellectual directions; some of them stem from analyzing underdevelopment. In what follows we outline some problems and issues which are fundamental in peripheral situations and that can be better understood if studied within the NISs framework of though.

(II.a) Inequality and innovation

Underdevelopment is usually associated with high inequality. The fight against it has always been part of the process of development, although with different orientations and outcomes. Two questions can be addressed here: i) which are the relationships between equity and innovation?; ii) are efforts towards innovation enough to improve equity in the long run? Regarding the first question it is useful to distinguish between "pro-active" or creative forms of equity -those that enhance innovation capabilities, thus allowing further social progress- and "re-active" forms, that hamper innovation. Pro-active equity can evolve from fair equity levels, like in Scandinavia, or from rather modest ones, like in Korea. What both situations have in common is, precisely, that the process towards higher levels of equity has been accompanied or even fostered by strong national efforts towards competence building and innovation. In these cases, equity tends to be further fostered. Re-active equity, on the contrary, describes a situation in which efforts towards diminishing inequity are based on distributing the fruits of static competitive advantages, without major efforts towards innovation and competence building. This has been the case of Uruguay during the first half of the 20th century, where the high prices of primary exports allowed the deployment of an early welfare state. Re-active type of equity makes equity fragile: once the good conjunctures that allowed its growth slow down, partly due to the weak efforts directed towards innovation, the equity situation stagnates or even has a reversal: Uruguay in the second half of the last century provides an example of this trend. (Arocena and Sutz, 2003a)

On the other hand, focusing on innovation without paying sufficient attention to equity has two negative results. The first one is that equity does simply not improve: Brazil is a case at stake. The second one is that if high inequality does not recede, growth-lead innovation cannot flourish, and so sustainable growth will sooner or later be hampered. In the end, inequity can even worsen.

The relationships between equity and innovation mold NISs and are influenced by them. Innovations of the "creative destruction" type usually do little to improve equity. Innovations of this type are associated with relatively high institutional isolation. When institutions related to higher education, research, productive investment and public policy are weakly interconnected and far apart from other institutions belonging to civil society, capabilities tend to become encapsulated, those in power tend to privilege immediate solutions without paying attention to long term competence building, and innovations seldom address specific problems of the less privileged. Moreover, when inequality is high, innovations can lead to further inequality not by intrinsic reasons but because of the asymmetries of the social fabric: "When the issue of equality has been investigated, we often find that the diffusion of innovations widens the gap between the higher and the lower status

segments of a system. This tendency for the diffusion of innovations to increase socioeconomic inequality can occur in any system, but it has especially been noted in Third World countries." (Rogers, 1995: 125) One of the causes of such phenomenon is directly related with social capital; in fact, when "early adopters" of innovators are studied (Rogers, 1995: 166-7, 269, 273), we can clearly see that they are on average much better endowed with social capital than the rest.

On the other hand, when equity tends to be a socially embedded value, innovation is geared towards problems that people want to see solved. This happens through multiple and complex institutional interactions, built over time and constantly evolving. Resulting NISs are quite different from those usually seen in underdeveloped nations.[5]

The expanding role of knowledge-based innovation should put the relations between science, technology and inequality in main positions in the research and policy agendas (Senker, 2003). Widening inequalities in general and learning divides in particular are rooted in these issues. It can be stated as a conjecture that the structure of NISs, that is, the type of issues addressed by its institutional setting and the way they are addressed, can have influence over the type and scope of equity in underdeveloped societies. Exploring this conjecture can lead to a new perspective on NISs, one that could help to search for proactive forms of equity. It seems that it is worth to include this in GLOBELICS' research agenda.

(II.b) Public perception of science, technology and innovation.

The legitimacy and efficiency of innovation policies is closely related with the opinions and expectations of different strata of population, including workers, entrepreneurs, technicians and engineers, and political decision makers. In a more basic way, those opinions and expectations mold the way people relate to science and innovation: hope, fear, indifference, rejection, pride or any mix of those feelings impinges in the evolving shape of national identities.

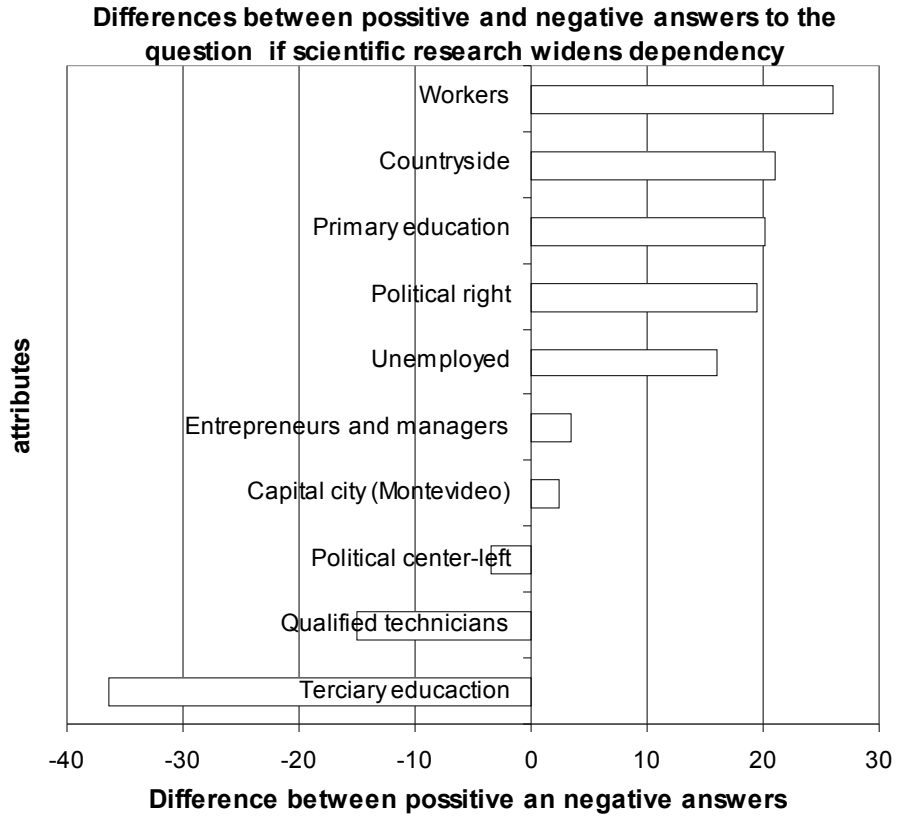
The impact of these feelings on learning prospects and innovation is not easy to evaluate. However, it is clear that in some places, many children rise with the knowledge that some of the heroes of world's science and technology were born in their countries. This knowledge forms part of their national identities, it provides "good" models to eventually imitate, it gives reasons to be proud of belonging to those places, it gives a sense of familiarity with something that has been, in part, made at home. Once they grow up and start reading newspapers or watching the news, they find again that science and technology breakthroughs often have as protagonists their countrymen (and women). Journalists know that even if local science and technology may not be so important, they rise interest in the readers, and so well trained professionals devote themselves to the task of informing about them. The main issue is that the endogenous production of knowledge, and the local utilization of knowledge produced everywhere to perform innovations, are perceived as an outcome of the country's dynamics. Innovation is not something that others do; it is part of the own identity.

[5] In underdevelopment, "grassroots organizations are often reactive: they criticize existing research projects or programs which they find unacceptable, instead of focusing on the development of alternatives" (Bunders, 1994: 102). The problem is that the development of alternatives, particularly those that want to take into account the needs of the weakest groups in society, is far more difficult than to simply say no to something. This is related to social capital. In the Netherlands, the experience of the "science shops" was possible because social capital was high: " 'science shops' within universities (were established) to ensure the access of groups without money and information to scientific developments. Science shops try to stimulate scientists to work for non-influential groups and prevent research undertaken for this groups being ignored or ridiculed" (ibid). This is an example, as well as the establishment and mandate of the Netherlands Office of Technology Assessment in 1987, of how equity concerns can mold NISs; the point is to better understand if some features of NISs can foster equity as well.

Things are different, obviously, in underdeveloped countries. This is not to say that no production of knowledge or innovation occur there; however, it has certainly little significance in world terms. Again, the impact of a collective "technological imaginary" in which science, technology and innovation is mainly something done elsewhere, is difficult to asses. Nevertheless, we can provide some empirical evidence on this matter.

In 1997, a national survey was conducted in Uruguay on public perception about innovation science, competitiveness and the future (Arocena, 1997). One of the question asked was if scientific research widens the country's foreign dependency. On the whole the result was that positive answers to that question outweighed the negative ones by 10.3 points. However, the balance between positive and negative answers varied widely with different attributes of the responders: this is shown in the graphic below.

In the extreme positions we find workers, people in the countryside and people with only primary education who exhibit a strong feeling that scientific research widens dependency from outside, and qualified technicians and people with university education that strongly feel the opposite. There is not a single explanation for this trend. For instance, the worker's opinion on this issue can be part of their general reluctance in face of science and technology –measured in other part of the survey-, probably issued from an association of science with more competitiveness in developed countries, or with the introduction of new machines, and the loss of jobs in Uruguay. However, as an hypothesis, it can be suggested that the two portions of the population that have opposed perceptions are in fact thinking on different objects while answering. The "culturally science weak" tend to think on the science they are acquainted with, the one they have heard about, that is, the "science from outside". Consequently, they associate this science with dependency. The "culturally science strong", are surely more aware that scientific research does not only mean science from abroad but also national efforts, and so they answer thinking about the "science from inside": their perception is radically different, and they amply deny any correspondence between making science and dependency.



As we have already mention, qualified technicians and people with tertiary education are a minority of the population in underdeveloped countries. If the Uruguayan example could give a more general clue, this would mean that the type of technological imaginary that the majority of people have, tends to visualize science as something that undermines their national self-esteem. This happens, at least in part, because they are not acquainted with the "inside innovations" that are really taking place.

We can propose as a conjecture that this issue affects the prospects of NISs in underdeveloped countries. Conversely, the NISs approach needs to integrate each technological imaginary into his focus to be truly able to understand the current dynamics of learning and innovation. This new perspective can also lead to efforts directed to shape the structure of NISs in a way that improves the technological imaginary in underdevelopment.[6]

(II.c) "Bio-innovation"

"Bio-innovation" has already become a great destabilizing factor, raising in new ways the issues of risk, ethics and conflict. From a development perspective, bio-innovation is important not only because biodiversity is highly concentrated in underdeveloped countries, but because research on life sciences is often strong there. If a "bio techno-economic" paradigm is emerging, a stronger relation with its knowledge base can perhaps open new paths to innovation in the South (Arocena and Sutz, 2003c).

Bio-innovation is important enough, and for so many reasons, that it deserves to be taken as a new perspective on the NISs approach. We shall briefly argue here why this is particularly so for underdevelopment.

A first reason is that life is always context specific, which leads to the unavoidable need for local knowledge to reach appropriate solutions for local problems. An example of this is the technology denominated Zero Tillage (ZT). ZT is a farm management system that minimizes soil disturbance and helps to reduce the use of agrochemicals. "ZT is the most important agricultural technology adopted in Brazil in the last 50 years." Many actors have a real or potential role in the "efficient innovation network" that emerged around ZT. (Eckboir, 2003: 584). "ZT technology is very sensitive to local conditions and requires substantial adaptation from one location to another" (ibid: 575). It requires long term research, in context. So it is an opportunity for local research.

A second reason is that some fundamental branches of the life sciences are particularly well suited for knowledgeable interactions; however, this remains as a not fulfilled potentiality for poor sectors of underdeveloped countries, partially because the of lack of well structured innovation systems. "In conventional organizations, fundamental research and applied research are separated structurally: different people, different organizations, different buildings. In biotechnological research, however, the two are extremes on a continuum." (Bonders, 1994: 159) This continuum character of research, that would allow users to enter in a fluid way into it through the expression of their demands, is often not exploited due to institutional difficulties.

"…in most Third World countries, agricultural research and extension are different functions occurring in separate institutions with different mandates and different ways of operating. Predominantly, the generation and transfer of knowledge….follows a top-down model: researchers develop superior genetic materials and/or production techniques, which they then turn over the extension services workers who demonstrate and disseminate them to farmers. Top-sown models function reasonably well in meeting the needs of both resources-rich farmers and large –and small-scale producers of high-value commodities. However…small-scale, resources-poor farmers, particularly those which work in relatively low-potential, heterogeneous agro-

[6] Interesting enough, the World Social Forum, which gathers "alterglobalizers" of all sorts, makes a big exception in its general anti-science and technology trends: the exception is open source software. Many reasons lye behind that. One of them is that the entrance to the club is not restricted, and that belonging to it does not imply for participants the need to leave their country.

ecological areas, have had no effective organizations through which to make their needs known. As a consequence, researchers do not receive enough information about these farmers' conditions and resources to set relevant priorities and goals." (Bonders, 1994: 155)

This can be understood as variation of the so-called *Innovativeness-Needs Paradox*, described as follows:

"The individuals or other units in a system who most need the benefits a new idea (the less educated, less wealthy, and the like) are generally the last to adopt an innovation. The units in a system who adopt first generally least need the benefits of the innovation. This paradoxical relationship between innovativeness and the needs for benefits of an innovation tends to result in a wider socioeconomic gap between the higher and lower socioeconomic individuals of a social system. Thus, one consequence of many technological innovations is to widen socioeconomic gaps in a social system." (Rogers, 1995: 275)

Exploring how to overcome the innovativeness-needs paradox in bio-innovation seems to be a valuable effort for the NISs approach.

A third reason is that around bio-innovation issues, new collective actors, both national and global, have organized themselves. Being the NISs approach particularly akin to study innovation from an actors' perspective, bio-innovation seems to be specially attractive. Some of these new collective actors are environmental NGO's and other social movements that strongly oppose prevailing trends in agricultural biotechnology (Parayil, 2003: 985). A further challenge here is to go beyond "what should not be done", to try "to influence the way biotechnology is developed and applied" (Bonders, 188). For this, stronger networking will probably be needed, something that needs better structured NISs.

A fourth reason is that bio-innovation has direct applications to health, nutrition and environmental problems affecting the most vulnerable part of the population. "Socially committed" research and innovation agendas are thus clearly devisable, and the enabling and hampering factors to put them to work can be studied with particular deepness.

A fifth and last reason is that the cognitive base of bio-innovation is relatively strong in many underdeveloped countries; this is a rare specificity of life sciences that deserves further analysis. In some cases, a sound knowledge base, stemming from long trends of accumulative learning, gave rise to important breakthroughs in bio-innovation. Cuba is one of those cases.

"Each years meningitis B kills 50,000children worldwide. For years Western scientists struggled in vain to develop a vaccine. Now Cuba's heavy investment in medical research has paid off. In the mid-1980s a deadly outbreak of meningitis B prompted the publicly funded Finlay Institute to invest in research, and it succeeded, producing a vaccine, providing national immunization by the late 1980 and selling the vaccine throughout Latin America" (UNDP, 2001: 98)

Bio-innovation can be seen, in underdevelopment, as an area where several actors are relatively strong and where goals are relatively clear: it is worth to explore if the innovation systems approach can help to better understand how to open this window of opportunity.

(II.d) Global regulatory systems

One main aspect of globalization is that "national government is locked into an array of global, regional and multilateral systems of governance". Notoriously, "in almost every sphere of social activity, from the economic to the cultural, there has been a significant institutionalization of transnational relations and networks". Concerning such trend, some "characterize the changing reach of international law as being ever less concerned with the freedom of states, and ever more with the general welfare of all those in the global system who are able to make their voices heard, such as corporations, pressure groups and so on". In any case, "in all major areas of policy […] the enmeshment of national political

communities in regional and global flows and processes involves them in intensive transboundary coordination and regulation. Political space for the development and pursuit of effective government and the accountability of power is no longer coterminous with a delimited political territory. Contemporary forms of political globalization involve a deterritorialization of political authority". (Held et al, 1999: 55, 57, 62, 81)

Formalized or mostly informal "multilateral systems of governance" are greatly influential concerning property rights, environmental protection, biodiversity, technological risks, investment regulations, trade and industrial policies, productive standards, etc. International regulations about such issues set something like "border conditions" for innovative trajectories, favoring some possibilities and hampering others. A global institutional framework for innovation is emerging. Of course, different countries have widely different weights in the setting of the formal or informal rules that are part of such framework, and the same rules have different consequences for different countries. Clearly, countries also differ widely concerning their possibilities for *de facto* rejecting a *de jure* accepted international rule.

It has since long been acknowledged the role of regulations –and of the lack of them- on innovation. Regulations affect relative prices, foster some directions of technical change while discouraging others, and create markets for new devises and new procedures. In developing countries, the lack of national regulations, or the weak capability to enforce existing ones, often hampers the diffusion of local innovations aimed at solving some specific problems. A typical case relates to environmental problems, where the implementation of locally designed solutions can find as its strongest barrier the ability of economic agents to avoid compliance with existing regulations. In cases like these, international regulations can open new opportunities for local innovation, because they usually come along with mechanisms of control and enforcement and have to be taken seriously into account, particularly for exports. In other cases, though, the outcome of international regulations impositions over national states can be not favorable at all to innovation and learning prospects.

In any case, it can be stated that the capability of nations to defend their interests in international instances where regulatory decisions with wide impact on innovation are taken, shapes their innovative paths. This is an issue to integrate into the NSIs framework, both at the descriptive and the prescriptive levels.

A good example of what we are saying is given by the current debates on intellectual property rights and their consequences for the South. It has direct implications on some problems previously discussed. Concerning innovation and inequality, a case a stake is the attempt of pharmaceutical multinational firms to prevent some countries in the South from using "generic" cheap drugs for healing poor people. By suing countries like South Africa, those firms were in fact hampering the possibilities of "re-inventing" aimed at making possible a wide diffusion of vital innovations. Concerning bio-innovation systems, their possibilities in many Southern countries are directly linked with a careful and science-based use and preservation of their rich natural endowment. This is an innovative path through upgrading traditional resources and knowledge, that may be blocked if biodiversity is severely damaged, as it is happening in many tropical zones of Latin America. Such possibilities are also being jeopardized by allowing to patent a vast array of information about biological processes. If such trends persist, the negative perception of science and technology in backward sectors and countries will increase. And innovative potentials will become even weaker than today. But alternative trends are also playing globally; some are fostered by international organizations and by an emerging "international civil society", where contradictory actions and proposals are displayed. Be it as it may, due to international civic mobilization, in a very notorious case some powerful multinational firms had to give up their attempt to prevent the use of "generic" drugs.

Of course, here we have only sketched one of the many aspects of a very complicated matter. We just want to emphasize that the differentiated impacts of global regulations and international institutions on national innovation systems deserve careful study.

Conclusion: on innovation policies and development strategies

Innovation policies understood as development strategies should be inspired by "gardening" concerns and include bottom-up based designs. A good gardener is fully acquainted with what happens in his garden and is primarily concerned with protecting his most promising plants. This approach to policy making is suggested because policies are needed not only to promote new things but to avoid that positive ongoing processes abort, and because policies should not be based on only formally existing organisms but on real strengths. If valid in general, these issues are particularly critic in underdevelopment. (Arocena and Sutz, 2003b)

One of the most illuminating emphasis of innovation scholars -emphasis on users- converge with development thinking in several ways, for example with Sen's recommendation about seeing people as agents and not as patients.

The same emphasis illuminates the analysis of a main social issue around innovation, that is, diffusion: "In general, centralized diffusion systems are based on a more linear, one-way model of communication. Decentralized diffusion systems more closely follow a convergence model of communication, in which participants create and share information with one another to reach a mutual understanding. A fundamental assumption of decentralized diffusion systems is that member of the user system have the ability to make sound decisions about how the diffusion process should be managed." (Rogers, 1995: 365) Focusing on National Innovation and Diffusion Systems can be a way to take into account user-producer interactions in an integral way.

Innovation policies as development strategies must include an orientation towards the long term. In this sense, we would like to briefly point out that foresight can be seen as an important tool for NIS building and gardening policies.

Martin (1996: 167) presents foresight tasks in a way that can be as well be valid for NISs, given that they may serve to articulate visions and actions of different sectors. In fact, as it is widely acknowledged, the main benefits of foresight efforts "lies not in the specific predictions but the process by which the forecasts are generated." This can be summarized as *the five Cs*: (i) Communication, between different peopled concerned with innovation. (ii) Concentration on the longer term. (iii) Coordination. (iv) Consensus, regarding a "shared vision of the future". (v) Commitment – "that what started out as predictions may then take on the nature of national goals". (Martin, 1996: 160)

From such point of view, we think that systematic foresight in an underdeveloped country can help the collective actors potentially involved in the NIS to:

(1) keep an eye on external opportunities and risks stemming from techno-economic changes in the North;

(2) detect and protect useful innovations when they are germinating, that is, when they are *faits porteurs de futur,* as the leading French foresight journal "Futuribles" calls them;

(3) contribute to forge truly national visions and strategies concerning development.

NSI is a concept that has made its way in political discourses all over the world. It has been taken with enthusiasm in many underdeveloped countries; however, a sort of "administrative view" of NSI has often taken the place of the kind of analysis the concept should foster. By the very fact of being so widely used, the NSI approach has acquired a sort of social responsibility. So it must keep on looking for new perspectives.

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