Looking at National Systems of Innovation from the South

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1.- Aims and content of this paper

All over the world the concept of National System of Innovation has entered into current policy discussions. The reasons underlying this new international discourse are well known:

- innovation has been recognised as a key factor for competitiveness, at both the business and the country level;

- innovation implies processes of change undertaken by firms that are affected by a broad set of economic, political, social, cultural, scientific and technological issues;

- many of these issues are direct outcomes of the purposeful action of organisations, public and private -including firms themselves-; some of them are unintended outcomes of organisations not directed primarily towards innovation problems; some, moreover, are related to the natural endowment and the history of nations;

- it is in the general framework or "climate" generated by these issues that firms decide and undertake innovative activities; framework or climate are both international and national in scope;

- even if globalisation heavily affects many -if not all- of these issues and the overall climate for innovation at country level, there is always room for "national influences";

- "national influences" can take the form of public policies -at macro, meso or micro level- and can also be the outcome of distributed initiatives coming from the most diverse social actors;

- it is recognised that it is important to analyse and understand how national influences on innovation operate nowadays and could possibly affect future outcomes;

- this is why a conceptual framework allowing for innovation descriptions, interpretations and actions is needed;

- the concept National System of Innovation -in any of its many definitions- provides such a conceptual framework and, more than that, establishes a positive feedback loop: to strengthen the

NSI is equivalent to improving the innovative climate and, for that reason, the feasibility of innovations.

This chain of more or less accepted statements has led to the "political correctness" and the recognised political importance of the concept. Of course, once this point reached, consensus and agreements begin to weaken. What exactly does it mean to strengthen the National System of Innovation? And even before that, what is to be taken into account when describing its main features and when trying to understand its dynamics? Since the beginning of the nineties a whole body of important academic work has been produced for analysing this type of questions; expectedly, many are the points of view presented**,** some of them even conflicting.

We are in a relatively early stage of the "life cycle" of the NSI concept. Charles Edquist wrote in 1997: "'Systems of innovation is a new approach to the study of innovations in the economy that has emerged during the last decade." (Edquist, 1997, p.1) At this early stage, the search for rigorous and precise definitions coexists with room for exploring connections even if sometimes these are more often derived intuitively than from tested theories of causation.[1]

From a political point of view, on the other hand, one of the most important exercises derived from the NSI conceptualisation consists of international comparisons: what kind of innovation policies are my neighbours, partners, rivals or "models" devising and implementing? Which of these policies could possibly be applied at home, and at what cost?

In this paper we deal with NSI from a Southern perspective: more precisely, from a Latin American perspective. We do not attempt strictly to make comparisons with the North, but to look into what has been produced in the North, regarding NSI with a "Southern head", even if we acknowledge that part of this head is fully international. We begin by stressing those characteristics of the concept that better illustrate a Southern perspective; then we describe a few of the main contextual differences between Latin America and the developed nations in terms of NSI

[1] An example of this type of exploration is the final remark Morris Teubal made in his article on the Innovation System of Israel. Referring to the Palestinian question in relation to some of the weaknesses and failures of the Israeli situation regarding innovation, Teubal wrote: "The mechanisms are subtle, but as with a lot of those insinuated in this chapter, they do not seem to be less real." (Teubal, 1993, p.497)

conceptualisation. After, we give an abbreviated account of recent empirical findings on NSI in Latin America or, more precisely, on the "really existent innovation" in the region; we also briefly describe some approaches devised to construct a picture that helps understanding the innovation dynamics and perspectives in a small Latin American country, Uruguay. Finally, some reflection on the lessons that can be learned from more mature systems of innovation is presented.

2.- A Southern perspective

To organise the perspective, we start by asking if the concept NSI refers to existing situations or if it names an ideal and not yet materialised configuration. When Christopher Freeman proposed the term National System of Innovation, in 1987, he certainly had in mind a very concrete situation: that of Japan. One of the reasons was the importance given to innovation in a strongly nationalistic strategy. But more distinctive than this seems to have been the "system" part of theNSI: many different things in different parts of the economy and the society at large appear to behave in accordance with the needs of other parts, as if many positive feedback loops were operating in a more or less synchronised way. An outstanding example of this is Freeman's description of Japanese education: the remarkable fact that so many engineers in Japan had formal basic science background, the practical training and frequent upgrading in industry of these very same engineers, and the concern with giving every worker some understanding of the relationship between various operation in the firm had as a result that "the 'system' approach is inculcated at all levels of the work force and not only at top management". (Freeman, 1987, p. 46)

Seen from a totally different standpoint, a second main branch of the NSI conceptualisation is in a similar manner built upon empirical observation. This is the case of the user-producer interaction approach to innovation, coming from the Nordic countries[2]. In an early work, Lundvall (1985, p. 3) develops the idea that an innovation is "the result of collisions between technical opportunity and user needs": the relationships between those who know about technical

[2] The opening chapter of the 1988 book edited by Freeman and Lundval, "Small Countries Facing Technological Revolution", under the explicit title of "Small National Systems of Innovation Facing Technological Revolution",

opportunities and those who supposedly know what they need are at the very center of the dynamics of innovation. The problem is that these relationships may become vitiated by various mismatches: opportunistic behaviour, heavy knowledge asymmetries between the partners, lack of cooperation, lack of "interdisciplinary" innovations. When this situations occur, unsatisfactory innovations take place. The improvement of user-producer relationships gives rise to many of the forms of the key social process associated with innovation, that is, learning. (Lundvall and Borras, 1997) The idea of a system of innovation in this work is associated with the institutions[3] that intervene in the learning process. These include of course universities but also specialised research organisations, science-based industries and other professional units engaged in production of tangible goods. Here, the national part of the NSI concept came from the very definition of innovation as the outcome of user-producer interactions: "If the cultural environment of a user is very different from that of the producer, it will be costly to establish a channel of information and to develop common codes. Not only will different national languages impair the communications, differences in culture will be reflected in different interpretations of identical signals." (Lundvall, 1985, p. 47).

The importance of users in the innovation process has been also put forward by scholars coming from a different empirical tradition. The work of von Hippel is particularly interesting in this regard and two of his conclusions or "synthesis" are particularly valuable: the conceptualisation of innovation as a distributed process and the systemic nature of that distributed process: "All of the elements in the examples I have just described can be seen as components in a distributed innovation process that clearly interact in a systemlike manner." (von Hippel, 1988, p. 121)

What are the most salient remarks that a "Southern head" worried about innovation can formulate in response to the above theorisation? The first is that NSI is an "ex-post" concept, that is, a concept built upon empirical studies that happen to show some similar patterns[4]. This is not trivial

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discusses the Nordic countries situation in terms of various systems, particularly those of producing, learning, searching and innovating.

[3] We are quite aware of the distinction between institutions and organisations, as formulated by North (1990) and stressed by Edquist (1997) in the search for a common lenguage regarding systems of innovation. Nevertheless, as both Freeman and Lundvall talked about institutions (even if in the organisation sense of the term) we follow that pattern.

[4] A good example of empirical evidence that supports the idea of National Systems of Innovation comes, not surprisingly, from Europe. In the second edition of the Directory edited by the Commission of the European

for a Latin American researcher on innovation problems, because in Latin America NSI is an "ex-ante" concept, in the sense that very few patterns of the socio-economic behaviour regarding innovation at national level can be viewed as working in a systemlike manner. This is not to say that innovation -technical innovation- is not present in the region[5]. The problem is that the micro-innovative strengths that really exist remain isolated and encapsulated, creating important difficulties for a further process of articulation and aggregation that could be synthesised in a NSI and create the impact a NSI is supposed to have on the competitiveness of national economies.

A second remark is that the NSI concept carries a normative weight. This is perhaps not a universally shared opinion. For instance, Edquist (1997, p. 20) writes: "…the notion of optimality is absent from the systems of innovation approaches. Hence comparisons between an existing system and an ideal system are not possible." In fact, to postulate the possibility of an optimal design for NSI would imply the dismissal of diversity, one of the main characteristics features of the NSI approach. Now, to discard the "ideal system" does not mean that the concept has no reference to what is "good" or what is "bad".

Lundvall stresses the fact that the extreme difference in competencies between users and producers lies behind unsatisfactory innovations or the slow path of innovation adoption, particularly regarding the modernisation of mature industries, like textiles and clothing. This is not a given fact of nature: he refers approvingly to the way MITI directed its efforts to modernise these sectors "as an attempt to compensate for the weak channels of information between producers and science based industries, and to break the inertia built into the traditional user-producer relationships." (Lundvall, 1985, p. 37, emphasis in the original).

Communities (1986), more than four hundred pages written with small types gave account of the most diverse type of incentives, instruments, mechanisms and policies devoted to the fostering of innovation and the creation and use of knowledge for innovation.

[5] We are entitled to use a broad scope to consider innovation, given that in an international comparative study Nelson and Rosenberg agree to consider innovation "the processes by which firms master and get into practice product design and manufacturing processes that are new to them, if not to the universe and even to the nation." (Nelson, 1993, p. 4)

An NSI that takes into account user-producer knowledge asymmetry will probably be more effective in the promotion of useful innovations that one that does not pay attention to this type of problem: it seems then that the NSI concept carries some normative weight.

Moreover, when Freeman first proposed the term, he did so in the context of a learning exercise, the sub-title of his book being "lessons from Japan": what can be more normative than the attempt to learn how something should be done? Acknowledging that there are some general "good ways" and some ways that appear to be "better" than others regarding NSI is important from a Latin American perspective: to avoid copying or just following the latest policy fashion some points of reference are needed, something like a normative guidance. This is not to say that there is "a" model for NSI in Latin America -or elsewhere-; it rather underlies a less emphasised feature of the concept -its normative weight- that is however quite important.

The third remark qualifies this normative weight a little more. The idea is that the NSI concept is "relational": almost all the literature on the subject stresses the utmost importance of the connections between different types of collective actors. Thirty years ago, an Argentinean physicist, Jorge Sabato, proposed an illustration for a "virtuous circle" able to put science and technology at the service of development: the "Sabato triangle" of entrepreneurs, government and academia. At that time, Sabato said that, no matter how strong each isolated organisation was, what was much more important was the strength of the connections between them: in fact the triangle exists at all only if the connections are there. This type of "relational" conceptualisation is widely adopted nowadays by innovation scholars, and from it derives an unmistakable signal of what is desirable and what is unimportant or prejudicial for the innovation process. In Latin America, it is a relatively easy task to create organisations to foster innovation, but it is quite difficult to make them operate as bridges between people. That is why it is worthwile to underscore the relational nature of the NSI concept.

A last remark is related to the debate about "creationism" or "spontaneous evolution" as paths development for NSI. It seems rather obvious that there is not a single answer for this debate:

it is easy to find more “creationist” and more “evolutionary” patterns for systems of innovation when comparisons between countries, between productive sectors, and even between different periods within the same country are made. The important point is that, given the state of development reached by each NSI, the future state and dynamic of the system can be at least partially influenced by purposeful action. That is, NSI is a policy subject. This does not mean that the whole shape of the system can be purposefully designed, nor does it mean that whatever policy or policy measure devised can be successfully implemented. But recognising that the NSI concept is a political concept and that the reality it describes can be submitted to deliberate efforts towards change with a reasonable hope to achieving what is intended is not trivial, at least in Latin America, where science, technology and innovation have never occupied a high position on the political agenda.

3.- Systems and industrialisation

The NSI concept covers industrial innovation -both technical and organisational. This is one of the reasons why we perceive such a wide distance between Latin America and the developed countries in the accuracy with which NSI gives an account of reality. If we instead focus our attention upon agricultural or agro-industrial innovation, this distance clearly shortens. If the “systems of innovation” concept had been invented several decades ago, it could have been fully applied to the agrarian or agro-industrial sectors of many countries, both in the developed and in the underdeveloped world.

Two remarkable “developed” cases are those of the United Stated and of Denmark. In the United States early public policy involvement in agricultural research, development, innovation and extensionism has been considered paradigmatic from a development point of view (Evenson and Westphal, 1995). In the chapter on the US National Innovation System of Nelson’s “National Innovation Systems” book (Mowery and Rosenberg, 1993), even if the focus is directed towards technical advance in industry, a short analysis of the agricultural sector is presented. Two reasons seem to explain this “deviation” from the main focus: the rather unique role played at the time by

the State and the insistence on a user-producer perspective organised around the extensionist philosophy.

The case of the U.S. early agricultural policy has been also analysed from a political science perspective that deserves attention, given the kind of issues it stresses. After underlining that by the period after World War I "the U.S. Department of Agriculture was an island of state strength in an ocean of weakness", the author goes on to say that the formulation of state policies were not only the outcome of powerful farm interest groups but also the result of "unique resources of administrative capacity, prior public planning, and practical governmental experience available to federal agricultural experts at the dawn of the New Deal." (Skocpol, 1985, p. 13-14) State will and state capacities combined for the development of systemlike initiatives to harness knowledge and innovation to economic growth in a particular sector.

If this emphasis on public policy initiative is perhaps too strong, the case of Denmark counterbalances it. Some analyses of the Danish NSI (Andersen and Lundvall, 1988; Edquist and Lundvall, 1993) include a thoughtful consideration of its agrarian system. And even studies not directed towards innovation issues gave a fascinating picture of the "collective action" which generated the very original relationship between material production and knowledge production in the Danish agro-industrial sector in the late nineteen century: "It was the farmers themselves who oversaw the development of an agricultural research system, and made sure that funds were available for the dissemination of research results" (Jamison, 1982, p. 284). [6]

Now, turning to Latin America, we can find many examples of articulated relationships between research, experimentation, extensionism and production in the agronomic sector that fit well with actual definitions of NSI. Uruguay is a clear case of this: quite early in this century the research part of the system was provided by the Agronomy School at the public university. The

[6] Moreover: "The farmers were opposed to a monopolisation of knowledge, and their scepticism was instrumental in keeping a modern patent system from getting established in Denmark until relatively late. When a patent law was finally established in 1894, the farmer's organisations had nonetheless seen to it that agriculture was exempted. Patents could only be taken on inventions that could be utilised industrially. According to one expert, Danish agriculture is unique in the world in its opposition to patents on the production of food products. This of course meant that all farmers could benefit from technological improvements, since inventions could not be.privatised. And it meant that agricultural research in Denmark could be integrated directly with production. " (Jamison, 1982, p. 284)

development part was secured through the university experimental agronomic stations; the extensionist part through courses taught in the vocational training system. There were also many public laboratories for agronomic purposes within the Ministry of Agriculture and a long tradition of tight relationship between some types of rural producers and the rest of the knowledge production and transfer system. Nowadays, the Uruguayan "innovation institutional map", that is, the set of organisations that include in a way or another goals related with innovation, is clearly much more dense when observed from the agrarian side than when this is done from the industrial side. The agrarian side, moreover, includes a particularly useful type of institutions unknown in the industrial sector: the Regional Centres of Agronomic Research, organised in productive clusters -rice, farm products, wine, barley- and of a totally private nature. The difference is not only in the number of organisations: "density" also refers to volume of research undertaken, producer participation in the setting of the research agenda, real use on the part of producers of the services offered and willingness to pay for these services. Perhaps even more telling is the fact that some sub-sectors in the agronomic landscape -wine being one of the most outstanding - have built a "micro innovation system" of their own that includes whole institutions ruled by the producers in which the State has delegated some key activities, like mandatory quality control. (Snoeck, 1998)

The question is then: why, during the process of industrialisation, has the gap between the present developed nations and Latin America in terms of NSI begun to widen? To put it in a nut-shell, the answer is related to knowledge. The agronomic sector needs knowledge suited to local conditions, and recognises, first, that there is a need, and second, that local scientific and technological efforts must be undertaken to fit this need. The industrial sector -in Latin America- has not exhibited this type of understanding. This is in part due to a general trend in developing countries: "In general, it has been assumed that industries in developing countries can acquire new technology fairly easy. For while the problems of transferring agricultural technologies among countries has been widely recognised, the difficulties of transferring industrial technology have not". (Bell and Pavitt, 1995, p.69). More generally, knowledge was not an important factor of

economic growth in Latin America. We now turn to a brief historical characterisation of that process.

In the decades following 1850 Latin America was incorporated as a "periphery" to the international economy which had its "centre" in the industrialised countries, thus starting a period of outward growth based on the exports of primary products. The ruling elites cared more about imitating the European elites way of life than of fostering the technological basis of economic growth. Since then a relevant proportion of the economic surplus has been dedicated to conspicuous consumption and related imports. And it was hard to find traces of the technological nationalism typical of the Japanese elites (Odagiri and Goto, 1993). In Latin America this was also a golden age for foreign capital. It was easier to buy modern productive methods abroad than to promote endogenous generation of technical knowledge; in the long run this was perhaps the main drawback of the period of outward growth (Bethel edit., 1991: 3). The official culture has, historically, marginalized science, except biomedicine an some other branches of biological sciences, and practically ignored technology; the "wedding of science and useful arts" that characterised the Second Industrial Revolution was scarcely noted in this continent.

Nevertheless, the fast growth of some Latin American countries around the turn of the century opened some opportunities for an incipient industrialization, specially when it was fostered by the rising consumption capacity of the middle classes. This was the situation in some regions where European immigration was very important, as in basin of the Río de la Plata and San Paulo. That immigration was the main actor of the industrial innovation and of the industrialising ideology on which economic progress was based when the world crisis of the 1930s led Latin America into a period of inward growth fostered by the Industrialisation by Import Substitution (IIS). This was the main period of development in Latin American contemporary history: roughly between 1940 and 1980, "despite the inefficiencies and distortions generated by forced industrialisation, investment and growth rates rose, the public sector initiated a vast expansion of basic education and standards of health improved substantially. Both these latter changes may well have been related to

urbanisation as much as to the creation of an industrial working class. None the less, this was not only the period of greatest structural change in the Latin American economy, but also one of sustained and relative stable growth and social improvement. In marked contrast, the 1900-40 and 1980-95 periods are ones of lower economic growth and much greater instability." (Astorga and FitzGerald, 1998: 20)

The State was a main actor of the IIS; its economic and social role expanded quickly. Also, the democratisation processes somehow weakened the control of the public organisms by small elites, the industrial working class and its trade unions grew, and at first the influence of foreign enterprises diminished. But strong traditional elites fought against the IIS policies and cultural undervaluation of technology prevailed. Consequently, although the States protected national industries, protectionism was not selective nor oriented to "learning"; generally speaking the States did not back firmly the upgrading of technological capacities and industrial activities in order to reach the level that is needed for the production of means of production. The result was "the truncated industrialisation of Latin America", as it is described in a fundamental but widely ignored book (Fajnzylber, 1983).

It must be stressed that during the IIS period, technological innovation probably took place throughout the continent in a wider scale than after 1980 (Katz, 1994). But, as suggested by the former considerations, it was highly informal and of an incremental or minor type. In Latin America, technological innovation has been undervaluated by dominant cultural patterns, scarcely studied by mainstream development economics, and almost ignored by public policies; thus, it was and still is a phenomenon of interstitial nature. The same happens with endogenous generation of scientific and technological knowledge. Technical change consisted overwhelmingly of imports of capital goods; as Celso Furtado stressed thirty years ago, the "peripherical condition" was fundamentally related to the "technological dependence" from the "centre". It still is.

Looking back to the main period of growth from the point of view of the Sabato's triangle of entrepreneurs, government and academia, we may conclude that only the "segment" State -

industrial sector really existed, with those connected with academia being mainly virtual. In some sense, the interactions between State and industrial entrepreneurs were "systemic", and undoubtedly they had a "national" focus. But at most we can think of a "National System of Industrial Growth". Strictly speaking, during the fast industrialisation period, in Latin America NSI were not built.

4.- The "really existent" industrial innovation in Latin America

If, strictly speaking, it is not obvious that NSI exist in these countries, what can we say about "really existing" innovation? Since the middle of the nineties, industrial innovation in several Latin American countries has been studied through innovation industrial surveys.[7] Mexico, Colombia, Venezuela, Brazil[8], Chile and Argentina completed these surveys between 1995 and 1998; in Uruguay a similar exercise took place ten years earlier, in 1988.[9] These surveys did not follow a previously agreed methodology but nevertheless, and partly because OECD Frascatti and Oslo Manuals have been a common reference, a fairly accurate set of comparisons can be established from their results.[10]

Some tentative conclusions regarding innovation in Latin America, based mainly on those surveys, can be summarised as follows:

i) national spending in innovation is quite low;

ii) innovative firms are characterised by performing indoors R&D;

iii) industrial innovation is highly informal, but

iv) not necessarily of a low level of complexity;

v) innovative firms have a comparatively important number of qualified technicians;

vi) firms without qualified personnel are not able to innovate;

[7] A detailed comparative analysis of these surveys has been made in (Sutz, 1998); the national surveys were presented in the II Latin American Workshop on Innovation Indicators, organised by the Latin American Network on Science and Tecnology Indicators, -RICYT-, October 1998, Caraballeda.

[8] The Brazilian survey is not a national one, but a survey of the Sao Paulo State, by far the most industrialised of the country.

[9] It is worth stressing that case studies about technological and innovation capacities in Latin American manufacturing sectors are known since long, the pioneering works of Jorge Katz in the seventies and eighties being a good example.

[10] The similarity in samples design as well as whole common sets of questions in the questionnaires allow reasonable generalisations of some important results.

vii) the lack of qualified personnel in small enterprises is not compensated by external advice.

Let us justify these assertions.

i) A first question is to determine to what extent Latin American countries can be considered as "individuals of the same species" (Nelson, 1993, p. 507) regarding innovation and R&D. A good proxi for that is to look at spending levels:

Table 1: Gross domestic expenditure on R&D as % of GDP, 1995

Argentina	Brazil	Chile	Colombia	Mexico	Venezuela	Uruguay
0,37	0,88	0,78	0,62	0,35	0,35 (1993)	0,15 (1994)

Source: Unesco, World Science Report 1998, p. 64.

The numbers are diverse, but one thing is clear: none of these countries has achieved the level recommended thirty years ago by Unesco to developing countries as a minimum threshold of R&D spending: 1% of GDP. In this sense, then, they are indeed individuals of the same species.

ii) A second question has to do with the criteria that were used to pick up the innovative firms within each country sample. They are also diverse, but in all the surveys the core of this question has been addressed through the internal R&D activities. The Colombian analysis concludes that for the innovative firms in their sample "the implementation of R&D projects is the most important element in the innovative process." (Duran *et al*, 1998, p. 89) This is a fairly common pattern and that is why analysing how Latin American industrial firms perform R&D becomes a central element for the study of the really existing innovation.

iii) The main conclusion we get from the surveys is that industrial innovation in Latin America is still highly informal. That is, even if a fair proportion of industrial firms perform both product and process innovation, R&D activities are not clearly and formally articulated with the enterprise strategy. We can use two indicators to support the above statement. The first is the difference between firms declaring innovative activities and firms reporting formal R&D departments or laboratories; the second one is the percentage of firms that report doing R&D and also know how much they spend on those activities.

Table 2.- Firms with innovative activities and firms with formal R&D laboratories as a % of the entire firms in each sample

	Argentina	Colombia	Mexico	Venezuela	Uruguay
Innovative activities	72,6	79,5	63,4	60,0	63,6
Formal R&D labs.	18,0	23,5	21,7	15,8	17,8

Source: INDEC, Argentina, 1998; Dto. Nal. de Planeacion, Colombia, 1988; Conacyt, Mexico, 1998; Conicit, Venezuela, 1998; Argenti *et al*, Uruguay, 1988.

As for spending, in Argentina about 25% of firms were able to declare the amount of money devoted to R&D, in Mexico 28,6%, in Venezuela 8%; in Uruguay, ten years earlier, more than 60% of the firms did not know how much they spend on R&D or they declared a negligible level of spending.

iv) The proportion of professionals in R&D is consistently higher than in other firm activities. The Mexican analysis shows that innovative firms were able to engage professionals in R&D activities even when not having formal R&D structures; in Uruguay, the proportion of professionals in formal and in informal R&D activities is practically identical. This qualifies the informal bias of Latin American industrial R&D: informality cannot be equated with low levels of complexity.

v) The correlation between innovativeness of firms and qualified personnel is quite clear in all the surveys. In the Colombian case, for instance, “the most striking relationship (between variables) indicates that the more qualified the staff, the more innovative the firms”: moreover, “the only indicators related to level of innovativeness, besides size, are the number of qualified personnel and their salaries” (Duran *et al*, 1998, p. 57). In Uruguay the analysis gave a similar outcome: the statistical correlation between level of innovativeness and number of engineers was highly significant.

vi) An important issue is to try to assess the innovativeness of firms in terms of its technical staff. That is, if we know which are the firms with good innovative performance, can we get some conclusions in terms of “appropriate” proportions of qualified personnel or “appropriate” absolute number of qualified technicians? The former is very difficult to establish given the non linear

characteristics of the relation between technical staff andall the employees. The latter is also difficult to establish, mainly because the more innovative firms in all the surveys are the bigger ones; these are, at the same time, the firms that have the greatest number of qualified personnel, and it is not easy to decide if their innovative performance is due to the number of their engineers or to other size related characteristics. But it seems that it is possible to find an absolute threshold of qualified personnel number under which innovation is very difficult to perform. The following table illustrates the point:

Table 3.- Average number of professional and post-graduate staff in the Colombian industry, by level of innovativeness and number of employees of firms

	First level	Second level	Third level	No innovative
20-49	1,1	0,8	0,3	0,3
50-99	4,4	1,6	3,0	1,0
100-199	8,6	3,5	3,1	2,3
200 and more	42,5	14,9	2,6	3,4

Source: Departamento Nacional de Planeacion, Colombia, 1998. First level means that the firms obtained international innovations; second level that they obtained national innovation; third level means that the firm, even not having obtained innovations, had made efforts in that direction; no innovative means that the firm have made no efforts towards innovation.

The table clearly shows that from 50 employees upward there is a sharp drop in the average number of the high level technical staff when passing from the first level to the second level of innovativeness, while for the smallest firms this drop is very small. This suggests that there is indeed a minimal threshold under which innovation is almost not attainable: one technical professional. The Uruguayan survey analysis allows the estimation of the number of enterprises that are below that threshold: 22,5 % of the firms of more than 100 employees did not have any engineer (in 1988); 50,3 % of the firms between 50 and 99 employees were in that situation and the same was true for 73,8 % of the firms between 20 and 49 employees. (Argenti et al, 1988)

vii) That trend is not particular to Uruguay and it points to a difficult situation for Latin American small and medium enterprises in a globalised economy that is more and more knowledge based and innovation and learning driven. But perhaps this is a premature conclusion: there are technical advice and research capabilities outside firms that could be mobilised to overcome the innovative weakness of SME. The following table suggests that this is hardly the case.

Table 4.- Utilisation of external technical advise by firm size (in %)

	Chile	Colombia	Mexico	Venezuela	Uruguay
Big firms	27,7	71,2	37,3	15,5	49,6
Medium firms	27,6	67,0	30,9	7,5	44,2
Small firms	16,0	55,4	18,2	3,8	38,6

Source: INE, Chile, 1996; Dto. Nal. de Planeacion, Colombia, 1988; Conacyt, Mexico, 1998; Conicit, Venezuela, 1998; Argenti *et al*, Uruguay, 1988.

Other empirical sources, mainly study cases on university-enterprise relationships show that the bulk of these relationships are established between university trained employees and faculty colleagues (Hein, Mujica, Peluffo, 1996); even to know what to ask and how to ask it, some level of training is necessary. It is more than possible, then, that the enterprises included in Table 4 are not precisely the ones that need to compensate their technical weakness through external help.

Much more information can be obtained from each individual survey, but further comparisons are difficult because of methodological differences; those stated are some of the main conclusions that can be established when comparing the "innovation part" of industrial innovation surveys in Latin America. Nevertheless, there is one more aspect that can be compared, namely, the "innovation system part" of the surveys. This part gathers information about the organisations with which firms interact in the innovation process and will be briefly addressed in the next section.

5.- NSI in the industrial innovation surveys: conceptual approach and empirical evidence

The world outside firms receives a lot of attention in all Latin American industrial innovation surveys. Many organisations are part of this world: other firms, be they suppliers, clients or competitors; scientific and technological organisations; research universities and other public or private research institutes; technical and business consulting firms; public programmes devoted to fostering innovation at the firm level. The way these organisations enter the scene is through their relationships with firms. Quite a diverse set of possible relationships are considered: origin of innovative ideas, sources of information for innovation, realisation of innovative projects, financial support for innovation, development of joint innovative projects. We can clearly recognise here the "relational" flavour of the systems of innovation concept. If we agree that these systems include the set of organisations that can possibly get involved in innovation driven interactions with firms,

the surveys do indeed reflect such a characterisation. However, the “national” qualification of these sets is not explicitly stated in the surveys: only the Mexican one contemplates a differentiation between national and foreign for all the organisations under consideration.

The main empirical findings may be summarised as follows:

i) The world outside firms is of relatively little importance regarding innovative performance: the ideas for innovation as well as the concrete implementation of innovations are, in all cases, mainly an internal affair.

ii) From this outside world, the less important organisations are universities and public research centres. In Colombia, universities are viewed as an origin for ideas on innovation by the 13,4% of the firms surveyed while the figure for public research centres is 7,4%: both cases have the lowest figures among all the organisations considered. In Mexico, innovation agreements were scarcely established with universities (6% of total) and public research centres (4,9%); nevertheless, these organisations constituted the most “national” of all the alternatives, in the following sense: 90% of all the universities and public research centres that entered into innovation agreements with firms were Mexican, in contrast to clients, which were foreign in 40% of cases, or enterprises of the same group, which were foreign in 50% of cases. In Venezuela, 43% of firms declared external technical relationships of all types; from these, only 3,5% have been established with universities and 4,5% with public institutions; more than three quarters of the firms involved in these relationships were big firms. The Venezuelan survey included a question about the way in which relations with universities and public centres were established; the most representative answer (45,2% of responding firms) being “informal contacts between firm staff and university faculty”. In Argentina only 6% of all firms in the survey declare having contracts with universities and public institutes. The figures for Chile are markedly higher: 31,8% of firms have received innovative ideas from developments undertaken in universities and 16,2% from public institutes. In Uruguay, in 1988, 27,2% of firms declared contracts with public organisations, 10% of them having been established with the University.

iii) If we include the acquisition of capital goods for innovation from other firms as an "external relationship", it appears to be the strongest for all countries. This is also valid regarding the future: augmenting the investment in machinery and equipment was by far the most frequent answer to the question about future plans in innovation. In all cases -with the exception of Argentina- machinery and equipment for innovation were overwhelmingly foreign.

At first sight, the evidence presented does not speak of a system and less so of a national system of innovation. Nevertheless, caution is necessary. Surveys alone give a much too general view to build a thorough picture of the national situation regarding innovation. That is why national study cases are indispensable, even though it is more difficult to make comparative analysis with them.

6.- Constructing a picture of NSI by combining different approaches

When trying to answer the question if a NSI really exists in a given country, it is necessary to take some decisions regarding what exactly will be studied in order to obtain a sufficiently accurate picture. The idea is to combine different approaches, each one able to shed light on an important aspect related to innovation, be it in the present or in a prospective view. The systemic character of the ensemble of innovation related processes can be thus estimated by the degree of compatibility or connectivity between those different aspects; in some sense we are thinking that the description of the system is like a picture, which exists only if it integrates different pictorial elements.

We have attempted to characterise the innovation landscape in Uruguay in this way[11]. Five basic approaches were chosen: the innovation strategies of selected productive sectors; the relationships between firms and universities or research institutions; the "innovation institutional map"; the innovative circuits approach and, finally, the collective visions approach.

[11] Two research projects were related with this aim: "Systemic Competitiveness and Innovation in Uruguay", sponsored by the Volkswagen Foundation and in an academic partnership with the German Development Institute of Berlin, and "Globalisation and Localised Innovation", sponsored by the Ministry of Science and Technology of Brazil and the Organisation of American States, in partmership with academic teams from Brazil and Argentina.

The first two approaches are pretty classic. The thorough understanding of the technological situation of a sector and of its innovations strategies gives precious information at a meso-level. The relations between firms and knowledge production institutions is, in its turn, a key aspect of the innovative landscape.

Through the third approach, the whole set of public and private institutions related in one way or another with innovation is identified and some of its characteristics are studied. In this way, an "institutional map" for innovation is constructed. A key question concerning each institution is the ensemble of national institutions with which it maintains some type of working relations: in Uruguay, the university was the institution most frequently mentioned in this respect. The vast majority of the institutions were mentioned only by two or three other institutions, showing a low degree of connectivity for the whole map, or, in other words, a rather isolated institutional setting. .

Inspired by the user-producer interaction conceptualisation, the "innovative circuits" approach consists of the identification and analysis of situations in which: i) pressing problems of production were solved by the encounter of actors having the problem with "knowledge" actors, be they faculty teams, public laboratories or high-tech firms, and ii) the learning process led to research on related problems, in a sort of growing spiral. These situations, studied at micro level, are very instructive concerning the reasons that these type of encounters take place, the type of difficulties that appear once the dialogues began, the ways in which they were mastered and, particularly, how the diffusion processes of the related innovations occur -if they occur at all. The diffusion process is central to this approach, for the very idea of an innovative circuit is associated both with the spread out of the innovation to other firms or even other productive sectors, and to the unchaining of upgrading consequences, like using the accumulated knowledge derived from the obtained innovation to go further in more sophisticated technological directions. An interesting innovative circuit detected in Uruguay was developed around the mouth and foot disease, relating cattle producers and a biotechnogy laboratory; others have developed around problems solved

through automation, microelectronics and molecular biology. In particular, analysis of the barriers to the diffusion of many of these innovations helped to shape the NSI picture.

The collective visions approach was based on a national opinion survey and a Delfos type prospective exercice.

The survey posed several questions concerning research, innovation, competitiveness and the future of the country. For example: does research promote economic growth, damage the environment, improve quality of life, stimulate unemployment, contribute to the export capacity of the country, foster dependence from abroad? Answers were related to several features of the respondents: age, socioeconomic level, education, ideological self-identification, etc. A huge amount of information was collected. In order to be very brief, we shall point out only two particularly interesting results. One that surprised experts was that a majority believes that research widens the dependency of the country from abroad; analysing age, educational level, place of residence, etc. we arrived at the following conclusion: those persons who are only slightly acquainted with the small but important research effort that has been carried on in Uruguay since the end of the dictatorship, in 1985, answer the question thinking primarily of “foreign science”, and so they assume that it widens the dependence of the country; on the contrary, more informed people think in terms of “national science” and so have a different opinion. People were also asked to choose between three “policy alternatives”: (i) Uruguay can and must do research with public funds, because benefits will be greater than costs; (ii) Uruguay can do successful research but must not do it, because costs will be greater; (iii) Uruguay cannot do successful research; 55% of the population chose the first alternative. Combining these results with other information, and remembering that national research has been historically a marginal activity in the country, with a small contribution to the quality of life, we may conclude that there exists a strong social basis for the promotion of science and technology, if it is carried on in a way that does not neglect some main concerns of the citizenry.

The Delfos exercise considered the opinions, on several subjects, of sixty persons: high public officials, relevant politicians of the main political parties, entrepreneurs, tradeunionists, economists and other academicians and international experts. We cannot summarise the conclusions here. Nevertheless, it may be stated that some kind of collective opinion emerged that stressed that this small peripherical country can and should point to a new model of development, based on quite specific innovation activities. "Competitiveness: where can Uruguay go?" was the title of the book based on this Delfos exercise. Its results suggested some of the questions posed in the national survey, and in turn the answers to them were analysed in the "second round" of the Delfos exercise. Thus, in particular, we can compare the opinions of the whole citizenry with those, in some sense, of the "elites". To give only one example: the former have a better opinion than the latter concerning the national capacities for innovation in general, for "doing new things". A closer consideration of this issue suggests that the main problems are not related with the capacities for technological innovation - which are supposed to be quite good- but with the capacities for institutional innovation, particularly in the realm of education.

The Uruguayan picture constructed upon these different approaches suggests that:

i) There are sufficient success stories of industrial technical innovation to support the idea that an innovation policy makes sense (the success stories relate to problems that are "country specific", in the same sense than agrarian problems).

ii) The institutional set up for innovation is weakly connected; this fact, united with the weakness of the institutions themselves, partially explain why success stories more often than not remain isolated anecdotes.

iii) People believe that endogenous research is worth a national effort but elites are so sceptical about the country's capacities for innovating at institutional level that a Nation's policy for innovation is difficult to implement.

Summarizing: there is fairly good technical capacity and ingenuity to solve pressing and specific production problems; common people, rather than being hostile to research, think that the country

should make an effort in that direction; weak institutional settings isolate and discourage innovation initiatives, and a low push to strongly improve the country innovative climate comes from the elites. To complete the picture of the strengths and weaknesses of the Uruguayan NSI we must stress that the demand pull of the productive sector for endogenously generated knowledge and innovation has been and still is quite weak.

7.- NSI in the South: some lessons that can be learned from the North

The innovation surveys analysis and the case study presented in this paper suggest that, in general, Latin American NSI are weak indeed. The reasons that they are weak cannot be limited to failures within the components of the system: the social and economic value historically assigned to endogenously generated knowledge and innovation are explanations at least as powerful. The question is then: value assigned by whom? As the Uruguayan case shows, there is not an unanimous "social subject" that speaks for the whole society: common people, technicians, elites, government officers, have different perceptions on the matter. It seems that in the developed countries, the picture we get of rather strong NSI is the outcome of a wide spread social consensus on the economic and political importance of the nation related capacities. The complex set of organisations, relationships and beliefs that the term NSI tries to capture has a macro policy expression, the innovation policies. These polices provide for the integration of "weak actors", like small and medium enterprises, into a more active innovative climate, thus expanding the social consensus. This is not to say that there are no conflicts: universities resent the push towards a more entrepreneurial spirit and workers discuss how to share the social costs of the jobless growth issued from actual technical progress. But there is still a strong consensus about the importance of knowledge and innovation both for the identity and for the future of the nation.

In this sense, to the four "Southern headed" remarks made at the beginning on the NSI conceptualisation -that is, its ex-post, normative and relational character, and the fact that it is

subject to purposeful action-, must be added a fifth one: its consensual nature regarding the social legitimisation of knowledge and innovation national efforts.

These remarks can be seen as “distances” between the Southern and the developed situation in terms of their NSI; those distances suggest some lessons and also warn against importing “turn-key” institutions and policies. In our opinion the most promising lessons are related to the “purposeful action” issue. They can be summarised as follows:

i) innovation policies are indeed a tool in the shaping of NSI;

ii) innovation policies are articulating devices;

iii) success is dependent on taking into account an actor’s perspective when designing interventions.

In the middle of so many fashions related to science, technology and innovation policies, whose appeal is precisely the claim that they follow the paths of the leading countries, these rather humble lessons may appear disappointing. We think, nevertheless, that if applied in a systematic way, and with due attention to the specifical problems and strengths of each “Southern” country, they might give good results and, moreover, fulfill an important goal for any learning exercise: to help further learning.

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