

# **The 1990s - a lost decade for the Brazilian NSI?\***

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F I r s t D r a f t

September, 2003

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\* - Prepared for *The First Globelics Conference 'Innovation Systems and Development Strategies for the Third Millennium* in Rio de Janeiro, Brazil, 02-06 November, 2003

## 1. Introduction

This paper deals with structural changes that took place in the Brazilian socio-economic formation throughout the 1990s and their impact on major elements of the Brazilian national system of innovation. Following a tradition which began with Freeman (1987){ XE "Freeman, C (1987), *Technology policy and economic performance: lesson from Japan*, London: Frances Pinter" } and Andersen and Lundvall (1988){ XE "Andersen, E and Lundvall, B-Å (1988), 'Small national systems of innovation facing technological revolutions: an analytical framework', in Freeman, C and Lundvall, B-Å, eds. (1988), *Small countries facing the technological revolution*, London: Pinter" } the major concern here is with interactions which take place amongst economic, social and political actors and which strength and/or limit their learning and searching capabilities in such a way that enhances and/or inhibits the development, diffusion, and use of innovations in a certain nation.

Despite the new framework for these interactions at times of increasing relations at the world scale, the national dimension is highlighted here in order to capture the spatial-institutional reference for interactions geared towards learning processes which lead to innovation and enhances / inhibits both enterprises' competitiveness and social capabilities. The Brazilian case is peculiar in the sense that most changes that took place in its institutional and economic set-up (privatisation, liberalization, change of ownership of major enterprises from local into foreign firms etc.) in the 1990s did not take into account the radical changes which were taking place in the technological basis of world development, i.e., those changes associated with the ITC techno economic paradigm [Freeman and Perez (1988)].

Thus, the paper revisits some of the dynamic elements of the Brazilian n.s.i. identified in the 1980s by Villaschi (1992). At the time, there were strong evidences that the role played by state-owned-enterprises; public run research laboratories in areas at the core of the ICT techno-economic paradigm (telecommunication and informatics); and the way the triple alliance between local, foreign and state-owned enterprises was working, could be a positive indication of possibilities for the Brazilian n.s.i. to take advantage of some 'windows of opportunities' that were being opened by the emerging techno-economic paradigm. . Moreover, these opportunities seemed to be supported by institutional changes that were being fostered by stronger social participation that were at the heart of the 1988 Constitution.

About a decade latter, this paper argues that some of these indications have failed to fulfil expectations raised by that earlier work. Even though the economy has overcome the historical problem of price instability, investment has had a poor performance in the 1990s; the liberalization of trade and capital flow has not brought foreign productive investment in areas where new knowledge is essential. In the technological domain, political commitment with public deficit has cut expenses in areas (education, R&D etc) which are crucial to innovation at times of the learning economy. Moreover, in the institutional domain, a strong belief in market forces by government officials, took the country to the position of no industrial / technological policies as its policy of economic development.

Thus, the paper brings evidence for what is stressed in the neo-schumpeterian literature; i.e., that the trajectories emerging from a techno-economic paradigm are seldom 'naturally' driven by market forces. Technological, economic and socio-

political factors are very important in shaping trajectories and determining the way a new technological base for world development is unfolded in different countries. These trajectories are shaped by a selection process, which takes place through the interplay of economic, political and social forces, and the localized scientific, technological, innovative and industrial capabilities.

Since the economic, social and political actors that comprise a n.s.i. do not respond to one single logic and the different logics they respond to are not necessarily convergent, the elements of the Brazilian n.s.i. highlighted in the paper will be divided into three self-regulated domains (technological, economic and institutional) which operate according to the hypotheses which were first established by Dosi (1984) and which were previously used by Villaschi (1992) in order to examine its main features in the 1980s. { XE "Dosi, G (1984), 'Technology and conditions of macroeconomic development', in Freeman, C, ed. (1984), *Design, innovation and long cycles in economic development*, New York: St. Martin's Press" }

Thus, the Brazilian national system of innovation (BNSI) is seen here in a way that it responds to basic features posed by Edquist (2001) { XE "Edquist, C (2001), 'The systems of innovation approach and innovation policy an account of the state of the art', presented at *The Nelson and Winter DRUID Summer Conference*, June 12-15, 2001, Aalborg, Denmark" }. Firstly, it consists of two kinds of entities. On the one hand, there are some kinds of components; on the other, there are relations between these components. Secondly, the reason why an array of components (technological, economic and institutional) and relations (especially those which are not mediated by the market) are chosen is because there are evidences that they form a whole. Thirdly, these components and relations are chosen in such a way as to make possible to discriminate the system in relation to the rest of the world; i.e. it must be possible to identify the boundaries of the system. That is, at least one actor of the learning, searching, innovating, producing process is within the country's geo-political boundaries.

The section which follows this introduction, presents the analytical framework which will be used in order to appraise the BNSI. This framework is based (i) on the contributions of Freeman (1988) and Lundvall (1988) regarding the n.s.i. approach and its critique made by Edquist (2001); (ii) on the works of Freeman and Perez (1988), Freeman and Louçã (2001), Castells (2000) and Tuomi (2001), regarding the on-going techno-economic paradigm; (iii) on the formulations of Johnson and Lundvall (2001), Nonaka and Takeuchi (1995) and Kuusi (1999) regarding knowledge and learning; and (iv) on the look that is given to institutions and social capabilities by Hamäläinen (1999) and Perez (1997).

Section 3 brings elements of the technological, economic and institutional domains of the BNSI in the 1990s. Special attention is given to the (i) downgrading of the country's university and research systems; (ii) weakness of economic policy regarding the stability and the flexibility which are needed if the country is to have a relevant role under the ICT techno-economic paradigm; and (iii) defensive strategy towards innovation which is being used by agents of production arrangements in the most developed regions of the country.

Given the evidences that the 1990s was a decade during which the BNSI worked under severe constraints, the last section deals with issues which are high in the

agenda of countries which want to play a more active role in the world flow of knowledge intensive goods and services and which should become a part of public debate and policy making in Brazil too.

## 2. The analytical framework

### a. *The system of innovation approach*

Following a tradition which began with Freeman (1987){ XE "Freeman, C (1987), *Technology policy and economic performance: lesson from Japan*, London: Frances Pinter" } and Andersen and Lundvall (1988){ XE "Andersen, E and Lundvall, B-Å (1988), 'Small national systems of innovation facing technological revolutions: an analytical framework', in Freeman, C and Lundvall, B-Å, eds. (1988), *Small countries facing the technological revolution*, London: Pinter" } the major concern here is with interactions which take place amongst all important economic, social and political actors and which strengthen their learning and searching capabilities in such a way that enhances the development, diffusion, and use of innovations in a certain nation.

This perspective stresses the differences in the rates at which countries exploit the possibilities offered by the technological gap which is opened especially at times of changing techno-economic paradigm or technological trajectories [Freeman and Perez (1988)]{ XE "Freeman, C e Perez, C (1988), 'Structural crises of adjustment business cycles and investment behaviour', in Dosi et al., eds. (1988)" }{ XE "Dosi, G, Freeman,C, Nelson, R, Silverberg, G e Soete, L, eds. (1988), *Technical change and economic theory*, London: Pinter" }. These differences are seen as dependent on each country's ability to mobilize political and financial resources for transforming the technological, institutional and economic structures which comprise its n.s.i.<sup>1</sup>.

As it is stressed in the neo-schumpeterian literature, the trajectories emerging from a techno-economic paradigm are seldom 'naturally' driven by endogenous scientific and technological factors. Economic and socio-political factors are very important in shaping trajectories and determining the way a new technological base for world development is unfolded in different countries. A selection process, then, takes place through the interplay of economic, political and social forces, and the localised scientific, technological, innovative and industrial capabilities.

In order to capture the main characteristics of the interplay that takes place at any country's level, a n.s.i. must be seen from two interconnected and, at the same time, opposite angles. The first is that of the 'disequilibrating' content of the forces which interact within it. This is because changes and transformations are by nature non-

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<sup>1</sup> - For a review of different aspects of the innovation systems approach, see Lundvall et ali. (2001), Edquist, ed. (1997). For critical comments on the approach, see Edquist (2001). Miettinen (2002){ XE "Miettinen, R (2001), 'Innovation networks, social capital and technology policy', Final report of the *Project Multidisciplinary Innovation Research and Technology Policy*, Helsinki: SITRA" } highlights criticisms to the concept, mainly with respect to the ways it has been incorporated in the Finnish technological policy discourse.

equilibrating forces. The second angle through which an n.s.i. must be seen is that of the forces that maintain relatively ordered the configurations of the system and allow a broad consistency between the conditions of material reproduction.

Since the economic, social and political actors that comprise a n.s.i. do not respond to one single logic and the different logics they respond to are not necessarily convergent, the elements of the BNSI highlighted in this paper will be divided into three self-regulated<sup>2</sup> domains (technological, economic and institutional) which operate according to the following hypotheses [Dosi (1984)]{ XE "Dosi, G (1984), 'Technology and conditions of macroeconomic development', in Freeman, C, ed. (1984), *Design, innovation and long cycles in economic development*, New York: St. Martin's Press" }:

- (i) regardless of the powerful interactions between them, each of the three domains has a dynamics and a content of its own. The specificities of each domain's dynamics and content shape and constrain their individual impact, and the interactions amongst them, in such a way that their functional feedbacks can make possible either 'virtuous circles' or 'mismatches';
- (ii) 'possible worlds' are limited by the number of configurations under which the three domains can operate in a relatively 'well-regulated' and smooth way;
- (iii) imbalance or 'mismatches' between the three domains do not necessarily lead to changes to other, more balanced or 'smoother' configurations,
- (iv) the adaptability of the technological system to a given economic and social environment is bounded and limited. Conversely, a relatively limited set of macroeconomic conditions and social relations are 'given' at each stage of the 'technological domain'.

#### *b. The ICT techno-economic paradigm as the basis for world development*

Even though the importance of the other three 'levels' (incremental, radical, changes of technology system) of innovation proposed by Freeman and Perez (1988) is recognised, here the main concern will be with the revolutionary ones. Two aspects of these revolutions are worth emphasising. The first one regards their widespread application and the drastic reduction in costs of many products and services. Secondly, it is important to pay attention to the technological revolutions' social and political acceptability. This can take longer than the perception regarding the technical advantages of the innovation and its economicity because in many cases such acceptability must be expressed in legislative, educational and regulatory changes.

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<sup>2</sup> - "The self-organisational approach to dynamic modeling proceeds from the observation that complex interdependent dynamical systems unfolding in historical, i.e. irreversible time, economic (political and social, my addition) agents, who have to make decisions today, the correctness of which will only be revealed considerably later, are confronted with irreducible uncertainty and holistic interaction between each other and with aggregate variables." [Silveberg et al. (1988), p.1036]{ XE "Silveberg, G, Dosi, G and Orsenigo, L (1988), 'Innovation, diversity and diffusion: a self-organisation model', *The Economic Journal*, **98**:1032-1054" }

Thus, Freeman and Perez's (1988) concept of techno-economic paradigm is a good approximation to Kuhn's elaboration because they relate technological paradigm not just to a particular branch of industry but to the broad tendencies in the economy as a whole. Moreover, they put together the inadequacy of existing institutions to the full development of a technological revolution, and the state of crisis that sooner or later emerges from its diminishing revolutionary character. That is, they give some real content to the notion of 'successive industrial revolutions' by interpreting the Kondratiev waves as increasing degrees of 'matches' between the techno-economic system and the socio-institutional framework in the upswing followed by increasing degrees of 'mismatches' between these subsystems in the downswing.

Besides breaking with different degrees of mono causal economic determinism, the techno-economic paradigm approach can be seen as an important move towards a more unified theory of growth, crisis and change. This heterodox approach seems more adequate than the vicious circle of mainstream social sciences where, on the one hand sociologists and political scientists try to explain weak social motivations, political apathy and political crisis in terms of economic trends. And, on the other hand, economists try to explain economic crisis tendencies as the result of the politicisation of the economy on motivations and incentives.

**Table 1. Changes in the techno-economic paradigm: from ‘cheap energy’ to chips**

‘Fordist’ (Old)	ICT (New)
<i>Technology features</i>	
Functionality and ‘better’ products	Knowledge and communication linked with human mind
Place-to-place connectivity	Person-to-person connectivity
People as ‘users’, ‘consumers’, ‘workers’	Personal, physical and psychological sustainability
<i>Economic features</i>	
Energy-intensive	Information intensive
Design and engineering in ‘drawing’ offices	Computer-aided designs
Sequential design and production	Consurent engineering
Automation	Systemation
Single firm	Networks
Product with service	Service with product
Centralization	Distributed intelligence
Specialized skills	Multi-skilling
<i>Institutional features</i>	
Government control and sometimes ownership	Government information, co-ordination and regulation
‘Planning’	‘Vision’
‘Welfare state’ and ‘warfare state’	‘Regulation’ of strategic ICT infrastructure
‘Pax Americana’ US economic and military dominance	‘Multi-polarity’ Regional blocs
US dominated international financial and trade regimes (GATT, IMF, World Bank)	Problems of developing appropriate int’l institutions capable of regulating global finance

Source: Adapted from Freeman and Perez (1988), Freeman and Loucā (2001), and Tuomi (2001)

This heterodox approach is even more important when one wants to deal with the on-going change in techno-economic paradigm. Even if one can trace its scientific and technological roots as far back as the XVII Century<sup>3</sup>, the so called information and

<sup>3</sup> - See, for example, Cortada (2000){ XE "Cortada, J (2000), 'Progenitors of the information age - the development of chips and computers', in Chandler Jr, A e Cortada, J, eds (2000), *A nation trasformed by information*, Nova Iorque: Oxford University Press " }

communication technology(ICT) techno-economic paradigm only became a part of the economic agenda after the 1970s. Moreover, its institutional implications only came to the open public debate in the 1990s.

No matter when each one of these three dimensions of the ICT techno-economic paradigm has surfaced in academic and/or public debate<sup>4</sup>, it is important to bear in mind that one should avoid the pitfall of single-factor determinism, whether cultural, economic, political, scientific, or technological determinism [Freeman and Louçã (2001){ XE "Freeman, C e Louçã (2001), *As time goes by - from the Industrial Revolutions to the Information Revolution*, Oxford: Oxford University Press" }]<sup>5</sup>.

For this reason, in here special emphasis is given to two features of the emerging era which are recognised as relevant by all those who are concerned with its opportunities and constraints: knowledge and institutions. If it were for nothing else, it should be because the main difference between previous waves / revolutions / societies / ages and the one we are living in is that today there are new/faster forms and new contents (social, political, economic etc) for collecting, treating, transmitting and receiving all sorts of information anywhere and everywhere<sup>6</sup>.

### *c. Information, knowledge and learning*

Modern economics is more than ever aware of the importance of knowledge and learning<sup>7</sup>. Within the field of innovation studies and technological changes, Nelson and Winter (1982) { XE "Nelson, R e Winter, S (1982), *An evolutionary theory of economic change*, Cambridge, Mass.: Harvard University Press" }, for instance, have made extensive use of the distinction between tacit and codified knowledge<sup>8</sup>; Arrow

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<sup>4</sup> - Freeman and Louçã (2001) remind us that even the Chairman of the United States Federal Reserve, Alan Greenspan, "...has spoken frequently of the 'new paradigm', referring specifically to computers, telecommunications, and to Internet as the source of the remarkable spurt of growth in the US economy in the 1990s." (ibid., p.301).

<sup>5</sup> - Elsewhere [Villaschi (2003), I explore alternative features of the ICT techno-economic paradigm indicated by Castells (2000), Drucker (2001) and Tuomi (2001)

<sup>6</sup> - Compare with Tuomi(2001)'s "... the ongoing socio-economic transformation is based on three interrelated processes of increasing informationalization, changing communications and interdependence structures, and changing processes of knowledge creation and utilisation.

<sup>7</sup> Johnson and Lundvall (2001){ XE "Johnson, B e Lundvall, B-A (2001), 'Why all this fuss about codified and tacit knowledge?', presented at *DRUID Winter Conference*, 18-20 January, Aalborg, Denmark" } reminds us that knowledge has been at the centre of analytical interest from the very beginning of civilisation. Aristotle distinguished between: *Epistèmè*: knowledge that is universal and theoretical. *Technè*: knowledge that is instrumental, context specific and practice related. *Phronesis*: Knowledge that is normative, experience-based, context-specific and related to common sense: "practical wisdom" (ibid., p. 12)

<sup>8</sup> - According to Gertler (2001){ XE "Gertler, M (2001), 'Tacit knowledge and the economic geography of context or The undefinable tacitness of being (there)', presented at *The Nelson and Winter DRUID Summer Conference*, 12-15 June, Aalborg, Denmark" } philosophers of knowledge such as Ryle (1949) { XE "Ryle, G (1949), *The concept of mind*, Chicago: University of Chicago Press" } and Polanyi (1958, 1966) { XE "Polanyi, M (1958), *Personal knowledge towards a post-critical philosophy*, Londres, Routledge" } { XE "Polanyi, M (1966), *The tacit dimension*, New York: Doubleday" } anticipated later developments in social constructivist thought by enunciating what was for them a crucial distinction between knowledge that could be effectively expressed using symbolic



(1962){ XE "Arrow, K (1962), 'The economic implications of learning by doing', *Review of Economic Studies*, **XXIX**(80): 155-73" }, Rosenberg (1976){ XE "Rosenberg, N (1976), *Perspectives on technology*, Cambridge: Cambridge University Press" }, and Lundvall (1985){ XE "Lundvall, B (1985), *Product innovation and user-producer interaction*, Aalborg, DK: Aalborg University Press" } raise specific questions regarding learning and innovation. The major difference between these contributions is that whilst the first two are more concerned with learning within the firm (by-doing and by-using, respectively), Lundvall's learning-by-interacting brings to the fore front of the discussion innovation capabilities which emerge when users and producers search together for a new product/process.

However, the understanding of knowledge and learning still remains narrow, despite new insights that emerge from historical and empirical research programmes on institutional economics, evolutionary economics, socio-economic research and the economics of innovation<sup>9</sup>. It must be credited to them the better grasp we have today on how innovation takes place in different parts of the economy. But, when it comes to the other aspect of knowledge production, i.e. competence building, learning and mediation of knowledge, research is only now beginning to raise fundamental questions about who learns what and how learning takes place in the context of economic development [Johnson and Lundvall (2001)].

In order to contribute to a better understanding of these issues, Johnson and Lundvall (2001) divide it into four categories. Individual<sup>10</sup> knowledge consists of know what ('facts'), know why (principles), know how (skills) and know who. The latter consists of information about who knows what and who knows what to do, and the social ability to co-operate and communicate with different kinds of people and experts<sup>11</sup>.

Furthermore, Johnson and Lundvall (2001) stress that very little knowledge is 'perfectly public'. Even information of the know-what type may be unavailable to those who are not connected to the right communications or social networks<sup>12</sup>. Even

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forms of representation – explicit or codified – and other forms of knowledge which defied such representation – tacit knowledge.

<sup>9</sup> - It is important to have in mind, however, that in theories that form the core of standard economics, it is assumed that rational agents make choices on the basis of a given amount of information. The only kind of learning allowed for is agents' access to new bodies of information.

<sup>10</sup> - According to these authors, on the organisational level the four categories correspond to 'shared information – data bases', 'shared models of interpretation (including company stories)', 'shared routines', and 'shared networks'. On the regional level they are identified as 'people', 'culture', 'institutions' and 'networks'.

<sup>11</sup> - The authors point out that this sort of knowledge has become increasingly important because there is a general trend towards a more composite knowledge base, with new products typically combining many technologies, each rooted in several different scientific disciplines. That makes access to many different sources of knowledge more essential.

<sup>12</sup> - That should be a matter of great concern for those who are working on the prospect of a new international order at ICT times. Since information and knowledge refers more than ever to power relationships, the 'haves' and 'have nots' in both inter and intra-country spheres cannot be considered a side subject for those who are investigating opportunities and constraints in the new/ next society/economy/paradigm.

if and when scientific or other types of complex knowledge is perfectly accessible, for accessing it the user must have invested in building absorptive capabilities<sup>13</sup>. They illustrate their point with the following considerations:

- (i) despite the fact that information technology has greatly extended the information at the disposal of individual agents, *knowing what* increasingly depends on selection of what is relevant. Even with the most recent advances in this area, access to this kind of knowledge is still far from perfect and the most effective medium for obtaining pertinent facts may be through the *know who* channel, i.e., contacting an outstanding expert in the field to obtain direction on where to look for a specific piece of information;
- (ii) scientific work aims at producing theoretical model of the *know-why* type, and some of this work is placed in the public domain. That, though, doesn't mean public access since it often takes enormous investments in learning before the information one might obtain through the Internet or other forms has any meaning. Again, *know who*, directed towards academia, can help the amateur obtain a 'translation' into something more generally comprehensible<sup>14</sup>. This is one strong motivation for companies' presence in academic environments and sometimes even engaging in basic research. Some big companies contribute to basic research and they tend to take over functions of 'technical universities'. This close connection between science and the exploitation of new ideas by business in fields such as biotechnology, though, can undermine the open exchange that should continue to characterise academic knowledge production<sup>15</sup>;
- (iii) in fields characterised by intense technological competition, technical solutions are often ahead of academic *know-why*. This is the case when technology can solve problems of perform function without a clear scientific understanding of why it works. Here, knowledge is more *know-how* than *know-why*.

Having addressed these different forms and contents of knowledge and their blurred public/private boundaries, Johnson and Lundvall (2001) come to another fundamental question specially for those concerned with the production, circulation

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<sup>13</sup> - "Know-how is never fully transferable since how a person does things reflects that individual's personality (even organisations have a 'personality' in this sense)" (ibid., p.15)

<sup>14</sup> - In this context the Finnish *Centre of Expertise Programme* can be seen as a model in terms of facilitating access to *who knows* where to find what is relevant and how to translate what is found in a way meaningful to business.

<sup>15</sup> - Johnson and Lundvall (2001) also stress that, contrary to the free 'spill-overs' which is assumed by standard economics, access to scientific *know why*, under all circumstances, depends upon investment in R&D activities and in science.

and distribution of knowledge, i.e., how can its different aspects be mediated. In this respect, they add:

- (i) since tacit knowledge in the form of *know-how* or competence cannot be separated from the person or organisation containing it, mediation may take the form of the purchase by the customer of the services of the person or the firm rather than the competence itself. The importance in this sort of mediation (and the problems it involves) can be noticed by the increasing relevance that has been acquired by knowledge intensive business services (KIBS);
- (ii) tacit knowledge can also be mediated through interactive learning between the one which needs it and its carrier<sup>16</sup>. This may be a conscious choice, for example when an apprentice enters into a contract with a master, or it may be a side-effect of co-operation between people and organisations to solve shared problems.

Mediation of knowledge is not necessarily easier when its content can be made explicit and it can be separated from its carrier. On the one hand, determining the value of the information for the user before the transaction takes place is not always an easy task. For obvious reasons, the user wants to know something in advance about the knowledge and the seller does not want to give information away for free. On the other hand, it is difficult both for the seller to restrict the use of the information once it has been sold; and for the buyer to restrict its further distribution by the seller.

In any case, it has been increasing the importance of R&D-expenditure as a means of facilitating the mediation of knowledge. On the one hand, because even to pursue reverse engineering takes a minimum of scientific competence which requires certain investment in R&D. On the other hand, since both the rate of change and the complexity of knowledge have been growing quite fast, no single organisation can master all the elements of the knowledge base<sup>17</sup>.

It is important to notice that even when knowledge is embodied into products, it might be necessary some kind of mediation for the transference of tacit knowledge in order

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<sup>16</sup> - Johnson and Lundvall (2001) point out that tacit knowledge can also be mediated through the hiring of the expert as employee or through the taking over of the organisation controlling the knowledge.

<sup>17</sup> - That is true both of high-tech areas such as biotechnology (see evidence presented by Walter Powel at workshop sponsored by Advanced Technology Policy Group/Minister of Industry and Trade, on 13/XII/01) as well as more mature fields such as the exploitation of natural resources like marble and granite [see Villaschi and Sabadini (2000){ XE "Hazley, C (2000), *Forest-based and related industries of the European Union - industrial districts, clusters and agglomerations*, Helsinki: ETLA / Taloustieto" }]

for it be fully and/or properly used. This is the reason why suppliers of complex process equipment may offer training to the personnel of the customer organisation<sup>18</sup>.

In all cases that have been presented by Johnson and Lundvall (2001) it is quite clear that at times of changing techno-economic paradigm, any attempt to have clear cut division between tacit and codified (or codifiable) knowledge is unfruitful. Thus, it becomes increasingly important to understand how these two forms of knowledge can establish virtuous circles of complementarities.

The SECI (socialisation- externalisation-combination-internalisation) model proposed by Nonaka and Takeuchi (1995){ XE "Nonaka, I e Takeuchi, H (1995), *The knowledge-creating company how Japanese companies create the dynamics of innovation*, Oxford: Oxford University Press" } is based on the idea that knowledge is created in a continuous process where the socialisation of tacit and unarticulated knowledge transforms it into a knowledge which can be transferred / codified. The combination of different externalised knowledge increases the tacit knowledge which is internalised into the individuals or the participating organisations. A virtuous circle is established when this new tacit knowledge is socialised.

Given that virtuous circles in many cases don't take place as a result of formal settings but are based on learning which is based on informal networks, more attention should be paid to 'learning communities'. The concept of 'learning community' is a way to describe basic actors and institutions interacting towards the implementation of different types of networks for learning. The defining functions of a learning community are its common knowledge management or knowledge logistics activities resulting in the adoption or in the production of innovations [Kuusi (1999){ XE "Kuusi, O (1999), 'Growing and learning entrepreneurial networks ad the focus of the national innovation strategy', in Schienstock and Kuusi, eds. (1999)" }].

A quick look at this model will be a strong argument for Johnson and Lundvall (2001)'s alert towards the need of better understanding the connections between different forms of knowledge, their public/private content and the different forms for their mediation. It will also serve for strengthening the context implication of tacit knowledge. That is, we need "... to think harder and more carefully about how tacit knowledge and context are *produced* before we can say anything intelligent about the conditions under which tacit knowledge can most readily be shared – that is, when 'proximity' is important: what types and why [Gertler (2001), p. 17]<sup>19</sup>.

#### *d. Institutions and social capabilities*

Consisting of both informal constraints (taboos, sanctions, custom, traditions, and codes of conduct) and formal rules (constitutions, laws, property rights), institutions in general terms "are humanly devised constraints that structure political, economic

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<sup>18</sup> - In the context of developing countries that is essential even when one is not dealing with complex process equipment. Low educated labour force implies that in those cases, this training is crucial if embodied knowledge is going to have any economic impact at all.

<sup>19</sup> - Which can be seen as an additional argument in favour of the NSI approach and a good reason to go to Karl Polanyi [Polanyi (1944){ XE "Polanyi (1944), *The Great Transformation*, New York: Rinehart" }] for a better understanding of the origins of tacit knowledge and context.

and social interactions.” [North (1991){ XE "North, D (1991), 'Institutions', *Journal of Economic Perspective*, 5(1): 97-112" }, p. 97]. They have as a basic feature their informational devices drawn to reduce uncertainties. By reducing the amount of information needed for individual and collective action, institutions make society possible and are a fundamental building block in all societies.

From an economic point of view, the institutionalist tradition has stressed the time and place dimensions that characterise regularities of social behaviour. Economic behaviour is instituted, then, not because of some universal human characteristics, but rather through a process of enculturation. In a world characterised by innovative activities (centred on different forms and contents of knowledge which is acquired through diverse sources and means of learning), uncertainty is an important aspect of economic life, and the existence of institutional set-ups at the different levels (of a specific firm, of a group of firms or of a country as a whole) become a central component of a system of innovation

Given these configurations, it should be of no surprise that in all the approaches that have been mentioned above, institutions emerge as a key element to be looked at. As highlighted by Freeman and Perez (1988), at times of changing techno-economic paradigms challenges emerge to the old institutional framework. The core resources, technologies, organisational arrangements, and market structures of the new paradigm cannot reach their full development potential within the old institutional framework.

If it were for nothing else, the old institutional setting was drawn (formally or informally) in order to match the socio-economic-technological needs and preferences of its time. Thus, as new socio-economic-technological needs emerge a new institution setting must come to place or a ‘mismatch’ occurs between the different domains described above.

Such a ‘mismatch’ can be seen from a perspective of the way agents (individual, groups, organisations) perceive the changes that are taking place. According to Hämäläinen (1999){ XE "Hämäläinen, T (1999), 'A techno-economic paradigm shift and the process of socio-institutional adjustment', in Schienstock, G e Kuusi, O, eds. (1999), *Transformation towards a learning economy*, Helsinki: SITRA" }:

- (i) there are those which develop a new attitude that better reflects the new techno-economic realities of the world, but are unsatisfied with the slow adjustment of social norms, formal institutions, and collective behaviour;
- (ii) others are satisfied with their old mental paradigm, but not with the way the economy and technologies are changing the world around them;
- (iii) still others which feel losses from the rapid structural change brought about by the techno-economic paradigm shift and cannot understand what went wrong with the society; and
- (iv) there are also those which do realise that changes are inevitable but given their vested interests on the old

paradigm (usually connected to human capital and physical assets) voice their protests against possible changes.

Due to these different perceptions and alternative behaviours, Perez (1997){ XE "Perez, C (1997), 'The social and political challenge of the present paradigm shift', presented at the *Norwegian Investorforum*, 15-16 May, Oslo, Norway" } points out that :

- (i) the long transition phase between the old and new socio-institutional paradigms tends to be a turbulent period of increasing social tensions, rising moral and religious fundamentalism, proliferation of new 'clans' and extreme movements, strong leaders with simple ideologies, and even wars and revolutions<sup>20</sup>;
- (ii) the adjustment of society<sup>21</sup>'s legal and regulatory framework can be a very slow process due to the resistance of many special interest groups and the complex nature of the political process;
- (iii) the institutional adjustment process influences collective behaviour. Public sector organisations and old special interest groups tend to be the last strongholds of the old institutional arrangement since they do not face direct competition and have strong interest in maintaining the old regime.

By now it should be clear that a system of innovation cannot rely only on economic relations which can be mediated by the market or whose governance can take place through hierarchies. At the level of the different social and economic networks, attempts must be made in order to quantify these relationships through the decomposition of social capital into three factors, namely social interaction, trust and the quality of information [Ali-Yrkkö (2001){ XE "Ali-Yrkkö, J (2001), *Nokia's network - gaining competitiveness from co-operation*, Helsinki: Taloustieto" }]

If one follows Coleman (2000){ XE "Coleman, J (2000), 'Social capital in the creation of human capital', in Lesser, E, ed. (2000), *Knowledge and social capital - foundations and applications*, Woburn, MA: Butterworth-Heinemann" }, social attributes / capabilities can be understood as institutional relationships between people. Under Putman's (1993){ XE "Putman, R (1993), *Making democracy work - civic traditions in modern Italy*, Princeton, NJ: Princeton University Press" } terms, they should be related to social networks, the norms of society and trust. Whilst using Fukuyama's (1995){ XE "Fukuyama, F (1995), *Trust: the social virtues and the creation of prosperity*, London: Hamish Hamilton" } contribution one could argue that social

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<sup>20</sup> - The events that took place before September 11, 2001 and the reactions afterwards illustrate this interpretation very well.

<sup>21</sup> - Here to be understood on different scales of space (local, regional, national, supranational) and other forms of social gathering (ethnic, religious, professional etc.)

attributes / capabilities include the ability of people to work with one another for the common good.

Whichever is the level at which one wants to understand common good, these social capabilities are of fundamental importance if a NSI is to cope adequately with scientific, technological, economic and institutional challenges and take full advantages of the windows of opportunities which emerge at times of changing techno-economic paradigm [Perez and Soete (1988){ XE "Perez, C and Soete, L (1988), 'Catching up in technology: entry barriers and window of opportunities', in Dosi et al., eds (1988)" }]. That is ever more so because societies differ with respect to the accumulated social capital and that has an impact on their capability to produce intellectual capital and to engage in innovation activities [Schienstock and Hämmäläinen (2001){ XE "Schienstock, G and Hämmäläinen, T (2001), *Transformation of the Finnish innovation system*, Helsinki: SITRA" }].

### **3.Features of the BNSI in the 1990s**

Given the characteristics of the on-going techno-economic paradigm pointed out in the previous section; and of the Brazilian socio-economic formation , two difficulties arise with respect to the analysis of the BNSI. The first one is related to the loose boundaries that exist between the technological, economic and institutional domains at times of change in paradigms.

The importance given by the approach used here to the innovative interactions that take place between different agents makes harder the task of placing each of them consistently in one of these three domains. For this reason, a degree of arbitrariness is inevitable when deciding in which domain to consider elements of the search and learning processes that take place in the system as a whole.

The second difficulty is related to what elements to take into account in the analysis. Given that the learning approach used here is closely related to an evolutionary perspective under which technological change is looked upon as an-open ended sequence of events, an important feature of the elements to be taken into consideration must be their contribution to the diversity and complexity of the system as a whole.

Moreover, the broader understanding of innovation under both the techno-economic paradigm concept and the n.s.i. approach implies that besides the economic-oriented factors such as diversity of products, production and trade patterns, attention must be given to institutional diversity which can affect the searching and learning capabilities of the n.s.i..

Having said that, the selection of elements to be used in order to characterize the BNSI in the 1990s will be those which are seen as evidence of either a positive response to the characteristics of the on going techno-economic paradigm; or of a constrain for the BNSI to play a more active role in the country's better insertion in the new forms and contents of the world economy.

#### *a . The economic domain*

The full impact of changes in economic policy that has occurred in Brazil in the 1990s is still an open issue for long discussions. The assumption that macroeconomic policies aimed at price stabilization and structural reforms along the prescriptions suggested by the Washington consensus, would generate a virtuous circle of gains in competitiveness following the phase of restructuring through liberalization of trade, de-regulation and privatization of state-owned enterprises, cannot be taken for granted for all economic activities in the country.

As shown by Coutinho (2001):

- the *Real Plan* for economic stabilization in Brazil had very high interest rates and resulted in a highly overvalued exchange rate right at the start;
- stabilization was based on a substantially overvalued exchange rate with a high and not easily reversible price tag - a structural increase in imports and a deceleration of the growth of exports;
- local industries increasingly came to substitute imported parts and components, made irresistibly inexpensive by the overvaluation of the exchange rate, for domestically made inputs;
- the share of imports in the composition of the country's supply increased and in many cases wiped out domestic production, leading to contraction of a significant part of the local industry;
- persistent financial vulnerability of Brazilian owned businesses resulting from very high costs of capital;
- weak competitive performance with outstanding trade fragility in all sectors of high added value and high technological content. Only the commodities sectors were internationally competitive with large scale production and low value-added - sectors that use raw material and agricultural inputs and are energy intensive<sup>22</sup>;
- widespread loss of national ownership in many sectors<sup>23</sup>, weakness and reduced size of the remaining Brazilian business groups, making it almost impossible for them to become active world players;
- increasing presence of foreign investors in all dynamic sectors having high value-added activities<sup>24</sup>. It is worth noting that direct foreign

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<sup>22</sup> - Quite in line with economic features of the 'old' techno-economic paradigm and further from what is considered the core of the on-going ICT TEP.

<sup>23</sup> - This serious debilitation of national business groups transferred the control of more than 200 important firms to foreign corporations. At least 50 of those had been publicly held corporations which then became fully owned closed subsidiaries.

<sup>24</sup> - According to IEDI (the institute for industrial development studies) between 1994 and 1998, the presence of foreign investors' control (% of sales of the 20 largest firms) moved from 55% to 79% in autoparts; from 34% to 79% in electronics; from 69% to 83% in computing; from zero to 75% in telecoms; from 44% to 73% in capital goods.



investment came to dominate important sectors of services and infrastructure which came to dominate important sectors of services and infrastructure which are non-tradable and therefore unavailable for export;

- Brazilian-owned corporations retained hegemony in the industrial sectors with low value-added (commodities such as non-metallic minerals, mining, paper and pulp, steels and metallurgy) and non-tradeables (construction and housing, transport services).

Under these circumstances, it should be of no surprise the negative effects that the macro-economic regime in the 1990s have had in the economic domain of the BNSI. Two empirical studies bring evidence of that in connection with the framework of cooperation, learning and embedded innovation capabilities which was established in the previous section.

The first one is the work done by Lemos et alii (2003) regarding innovative capabilities in the Fiat suppliers network in Minas Gerais state<sup>25</sup>. It shows that:

- in contrast with the 'mineirization'<sup>26</sup> of the auto-parts industry launched by Fiat in 1986, throughout the 1990s there was an increasing 'Italianization' of the Minas Gerais auto-parts industry. That was so because Fiat stimulated the entry of familiar suppliers that they have had a long-lasting relationship with in Italy. As a result, while in a sample of 42 Fiat suppliers interviewed in 1994, 81% were national; in another one of 20 suppliers interviewed in 2000, 60% were subsidiaries of global suppliers;
- despite good availability of local research groups in mechanical engineering, interaction between them and Fiat's local vertical supply chain is very weak. A good reason for that might be that close to 60% of respondents to Lemos and colleagues' survey consider their in-house R&D labs outside the country as the main source of information related to innovative activity;
- co-design activities are virtually absent in Brazil, except in those cases where the adaptation of the component to local conditions is necessary. Thus, there is very low spill-over to the local system of innovation as local suppliers are not expected to have an independent capability to perform design activities and, at the same time, to be able to solve problems jointly with the assembler;
- there is evidence of lack of cooperation between competitor firms and between second- and third-tiers suppliers, and between them and

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<sup>25</sup> - One of the top three most industrialised states in the country.

<sup>26</sup> - Referring to the installation of suppliers in Minas Gerais.

suppliers of raw material and equipment. Only two aspects of cooperation appear to have increased of intensity: exchange of information and trials for development and improvement of product. The explanation for the increase in the intensity of cooperation seems to be related to the search for quality in both input/equipment and personnel (through training);

- R&D activities have almost vanished in this industry in the region: (i) only 18 Fiat suppliers have patents registered in Brazil. As of 2000, the number of patents totaled 87 and most of them were of a simple content ; (ii) before the economic liberalization and the emergence of the global car, Fiat's engineering department in Minas Gerais employed almost 400 people. As of 2000, the department had shrunk to no more than 100 employees;
- The fact that the main R&D labs are based outside the country has been decisive in explaining the low interaction between agents regarding the development of technological capabilities. Moreover, the weakness of the transmission mechanisms of inter- and/or intra-industry and vertical and/or horizontal technology transfer has compromised the intensity and the spread of spillovers effects.

The second study [Szapiro (2003)] brings evidence of the telecommunication industry which is at the core of the ICT techno-economic paradigm and that was praised by many as a success story of the BNSI in the 1980s [see Hobday (1990), Pessini (1986), for example]. It shows that

"... the structural reforms of the 1990s provoked great disarray in the Campinas arrangement<sup>27</sup>, eliminating firms and abolishing cooperative linkages between institutions. As a consequence of these troubles, learning processes accumulated in the past have been put into jeopardy. There is serious doubt about the possibility of maintenance of local technology development. The processes of trade liberalization and deregulation have thus promoted disarticulation and destruction of intangible assets of firms and institutions, deeply affecting their core competences." (ibid, page 496)

As for trade liberalization, she shows that, even though, it didn't provoke significant changes in the structure of the telecommunications equipment industry, it, on the one hand, significantly affected the strategies and capability development of the nationally owned firms in a way that it reduced their internal technological development. On the other hand, multinational subsidiaries that were in Brazil before the beginning of the 1990s, increasingly based their industrial and technological capabilities building on their headquarters, and on other subsidiaries of the same group in the direction.

As far as privatization is concerned, Szapiro (2003) stresses that: (i) there was a considerable increase in the share of telecommunications sector in the trade deficit of the electronic complex (reaching more than 40% in 1999); (ii) there was a change in the mix of activities conducted by CPqD<sup>28</sup>. It reduced the number of research

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<sup>27</sup> - Which comprises over 85% of telecommunication's equipment industry in Brazil.

<sup>28</sup> - An important milestone in the effort to set up a national and independent model for the telecommunication industry, CPqD is an the R&D centre established by state-owned Telebras

projects it used to undertake and increased the share of short-term consultancy and technical assistance activities it provided as a survival strategy.

The strong dependence of the subsidiaries of multinational firms on their parent companies abroad, became an inhibitor to knowledge flow and interaction with local educational institutions. According to Szapiro's survey:

"The reasons given by multinational subsidiaries to interact/cooperate with other institution are qualification and training of human resources and product commercialization (the case for 80 per cent of firms). For them cooperation takes place to support personnel training and facilitate product commercialization. On the other hand, all nationally owned firms declared that access to technology is the main reason for the interaction with other institutions. ... It is interesting to notice that the subsidiaries' behavior differs from that prevailing at the end of the 1970s and the 1980s. During this period, some projects were developed between multinational subsidiaries and CPqD, as a result of the policies implemented in the sector" (ibid., page 491)

She also quotes Souza and Garcia (1999) in order to show a shift in the reason why firms looked for that specific location. Those that were installed in Campinas before the 1990s said they had chosen it because of its provision of easy access to R&D and education institutions. As for those which went there in the second half of the 1990s, their location choice was based on the availability of labor skills and a well developed road system<sup>29</sup>.

If one moves from cases such as Fiat's suppliers, in Minas Gerais, and telecommunications, in São Paulo, situations can be found where the general framework of economic policy mentioned above had contradictory impacts on the innovative capabilities of the micro-foundations of the BNSI - that of productive arrangements (APL). That is, if, on the one hand, the overvaluation of local currency caused fierce competition from abroad which was fuelled by lowered tariffs on imported goods; on the other hand, the exchange devaluation favored the modernization of their plants through the import of capital goods at lower relative costs.

In the case studied by Campos, Cário and Nicolau (2003), that of the textile and clothing in Vale do Itajaí, equipment import have not produced internal effect which have directly encouraged interactions for innovative learning apart from the incorporation of new technologies embodied in equipments. In other cases, evidences have been found of improvement in the innovation capabilities of local companies/organizations, even if specific and restricted to some elements of the respective arrangement.

Thus, the APLs of shoe making in Rio Grande do Sul [Vargas and Alievi (2003)], of textile and clothing in Vale do Itajaí, and of metal mechanic in Espírito Santo [Villaschi and Lima (2003)], have been urged to improve their capacity to meet

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in the 70s, with the objective of becoming a reference for the country's research and development projects for equipment and services in that sector.

<sup>29</sup> - In the terms established in section 2 of this paper, it is as if the BNSI were going back from the 'new' into the 'old' TEP,

client's short run demands. It should be emphasized that in the majority of cases such qualification was restricted to process innovation

Other empirical studies can be used in order to illustrate the perverseness of liberal economic policies practiced in Brazil throughout the 1990s. de Paula, Porcile and Scatolin (2003), for instance, show that in the case of the Soy APL, in Parana, two changes have had negative effect on its technological capabilities.

Firstly, that in R&D strategies by the main source of innovation - EMBRAPA (state-owned institute for the scientific and technological development of agriculture) - which does not allow for co-property of new varieties any more. Secondly, the modifications in the legislation that regulates the production of new varieties and which ensures private appropriability of innovations through patenting.

These two changes have just about vanished the co-operation system for the recommendation of new varieties which used to make possible EMBRAPA's strategies for the development of seeds through close ties with small and medium sizes producers / co-operatives. It should also be noticed that these changes have taken place at the same time that there has been a substantial entrance of multinational soy seed producers in Brazil. And there, just as it has been pointed out in the cases of Fiat's suppliers and of telecommunications, that has meant a transference of innovation capabilities towards the multinationals' laboratories in their home countries.

#### *b. Institutional domain*

As stressed in section 2, in a world characterised by innovative activities (centred on different forms and contents of knowledge which is acquired through diverse sources and means of learning), uncertainty is an important aspect of economic life. For this reason, the existence of institutional set-ups at the different levels (of a specific firm, of a group of firms or of a country as a whole) becomes a central component of a system of innovation. In such a world then, institutions move beyond the characteristics of routines, and guiding every day life in order to work also as a framework for change.

Mytelka and Smith ( 2001 ) emphasize that the recognition of the need for this framework for change can be increasingly found throughout the 1990s in policies drawn within the countries of the OECD. In this same direction, Edquist (1997) points out that the n.s.i. approach was used as "...a means for studying innovations, as a conceptual framework for government policy-making, and as a basis for formulating the innovation strategies of firms." (ibid.,page 16).

Edquist (2001) goes further in order to stress that the national system of innovation approach established itself at a relatively short time, and began being used widely not only in the academic milieu as in the establishment of innovation policies as well. In a similar way, Miettinen (2002), recognizes that the concept created fabrics of

policy language woven by researchers together with bureaucrats and civil servants which made it work as an organizing boundary<sup>30</sup> metaphor.

One question that must be asked, then, is why the n.s.i approach did not go beyond innovation studies in Brazil; why as a conceptual framework it was not even considered for policy-making in government or as a basis for formulating the innovation strategies of firms.

The work by two Uruguayan colleagues might help to shed light into these questions. Arocena and Sutz (2002) indicate that, despite being recognized as 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, the n.s.i. approach can not be seen as trivial. That is so because, even in order to taken as a political concept, it needs social attitudes concerning global transformations.

According to them, "Social attitudes concerning global transformation belong to those issues that deserve special attention in Hirschman's approach: "Our diagnosis is simply that countries fail to take advantage of their development potential because, for reasons largely related to their image of change, they find it difficult to take decisions needed for development in the required number and at the required number and at the required speed" (Hirschmand, 1958: 25)" [Arocena and Sutz (2002), page 15].

One could say, then, that a major constraint for a better 'tuned' institutional set-up of the BNSI in the 1990s was a lack of 'vision' (see table 1 in section 2). According to Fransman (2002), "A 'vision' or cognitive framework consists of a interrelated set of beliefs, embodied in assumptions and expectations, which serve the purpose of making the world seem intelligible and therefore orienting decision-making" (ibid., page 8).

Since the dominant image in the 1990s among economic policy makers in Brazil was concerned with competitiveness based on factor endowments (mainly natural resources and cheap labor force), it should come no surprise the fact that not much was done concerning the opportunities and constraints which emerged with the ICT techno-economic paradigm. That is not to say, however, that the subject was totally missing in the government's agenda.

Contrary to what took place with the n.s.i. approach (which was the subject of only a couple academic works and never moved beyond seminars / libraries' walls), (i) the need for proper funding of innovation and technological development; and (ii) a

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<sup>30</sup> - "The concept of the boundary object was originally introduced by Star and Griesemer in 1989. Bowker and Star define the concept as follows (1999, 297): Boundary objects are those objects that both inhabit several communities of practice and satisfy the informational requirements of each of them. Boundary objects are thus platic enough to adapt to local needs and constraints of the several parties employing them, yet robust enough to maintain common identity across the sites. They are weakly structured in common use and become strongly structure in individual site-use. (...). Such objects have different meaning in different social worlds but their structure is common enough to more than one world to make them recognizable, a means of translation. The creation and management of boundary objects is a key process in developing and maintaining coherence across intersecting communities." [Miettinen (2002), page 19]

certain awareness about the challenges of the 'information society', can be found in different levels of public debate.

Those are certainly the cases of the attempts to establish 'ear marked' money for funding S&T projects. The first one, took place in the Constitution of 1988 which allowed governments at the state level to commit a certain percentage of its revenues for S&T financing. The second one, was the movement among federal government officials with the support of committed (but of restricted numbers) members of Parliament and business people, in the direction of guaranteeing funding for R&D in thirteen economic areas<sup>31</sup> and for universities' S&T infrastructure.

Despite the political victories of both, they did not present substantial results in the 1990s. On the one hand, even though most states have adopted in their constitutions the principle of committing funds for S&T, the letter of the law did not have a practical response. In most cases, the amount of money which appears in the states' budgets does not become financial resources during the year for research projects. 'If budget control is necessary, the first expenses to be sacrificed are those which have the least public appeal', is a popular saying among those who are responsible to keep public finances balanced.

On the other hand, the Ministry of Science and Technology's project to guarantee stable funding for S&T at the federal level, had its first account<sup>32</sup> (that for petroleum) established in 1999. Thus, this project's effectiveness concerning its main aims (stable funding, fostering university-enterprises closer ties, promotion of S&T research, prioritization in the use of resources, monitoring of results) will only be able to be assessed at a latter stage.

Attempts have also been made to increase awareness about the new challenges and opportunities which emerge at times of changing techno-paradigm. Once again, at the level of the Ministry of Science and Technology, work was done

"in order to bolster the development of the New Economy in our country, we must encourage the utilization of these technologies in Brazilian businesses, which is the goal of the Information Society Program - one of the most ambitious programs of the 'Advance Brazil' development plan and the result of efforts initially undertaken in 1996 by the National Science and Technology Council. Its main purpose is to establish the foundations of a nationwide strategic project to integrate and coordinate the development and employment of advanced computer, communication and information technologies and their applications in society. This endeavor will allow the government to further research and education, as well as assure that the Brazilian economy is capable of competing on the world market" (Ambassador Ronaldo Mota Sardenberg, Minister of State of Science and Technology, on September 13, 2000, when *Information Society in Brazil - Green Book*, was launched)

No matter how well intentioned was the Minister and a few of his colleagues in different spheres of government, academic and business life, the late launching of a program geared towards the information society in Brazil, had the same fate of others in the above praised 'Advance Brazil' : lack of proper funding and of continuity due

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<sup>31</sup> - petroleum, infra-structure, energy, hydro resources, transports, mineral, space, telecommunications, information technology, health, aeronautics, agribusiness and biotechnology

<sup>32</sup> - As part of the FNDCT (the national fund for the development of science and technology), created in 1969 but which lost its effectiveness as its funding were being mitigated since the 1980s.

to low political commitment at the spheres of government where effective decision takes place.

It should be stressed, though, that this sort of gap between what is thought at the level of those committed to science and technology in Brazil, and those who actually manage economic policy with a pragmatic short run approach, is not new in recent history. On the one hand, as pointed by Jaguaribe (1987), it was present many times during the country's late industrialization process when the government had to take a stand on what model of 'leap-frog' to adopt: that based on imported embodied technology; or that aimed at medium- and long-term internal technology capability building.

On the other, as it is highlighted by Piragibe (1988), it was also rooted in the history of informatics policy in Brazil. In the 1980s there was fierce debate within government between those who wanted to protect internal computer market as a way to foster industrial and innovation capabilities in that industry; and those who wanted to avoid retaliation from the USA that threatened to close its market to commodities such as orange juice, shoes etc..

### *c . The technological domain*

Given the general constraints imposed to the BNSI by liberalization, privatization and by the ideas behind economic policy throughout the 1990s; and taking into consideration the general institutional framework mentioned above, it should come to no surprise the poor performance of the technological domain of the Brazilian n.s.i..

Even when not explicitly mentioned, the evidence which will be brought in here must be seen from a perspective which takes into consideration the technological features of the 'new' paradigm as indicated in Table 1. That is, knowledge and communication, linked with human mind; person-to-person connectivity; personal, physical and psychological sustainability

Moreover, the evidence will go beyond the discourse that many times is a response of awareness by people in academic, government and private sector. That, however, is not sufficient, by itself, to break with rigidities such as the one pointed out by Hamäläinen (1999) and Perez (1997), mentioned above.

Thus, for example, even though the beginning of the 1990s was marked by the introduction of several national initiatives in the computer area, under the auspices of the Ministry of Science and Technology, such as <sup>33</sup>:

(i) National Research Network (*Rede Nacional de Pesquisa - RNP*), aimed at implementing the Internet for educational and research purposes in the entire country;

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<sup>33</sup> - For details on these programs and other initiatives on information society in Brazil, see [http://www.socinfo.org.br/livro\\_verde/ingles/implem.htm](http://www.socinfo.org.br/livro_verde/ingles/implem.htm)

(ii) Thematic Program of Computer Science (*PROTEM-CC*), aimed at structuring and supporting a model of research through a consortium between academic entities and the private sector;

(iii) National Software for Exportation Program (*Programa Nacional de Software para Exportação - SOFTEX*), aimed at structuring and coordinating a nationwide effort to significantly boost the exportation of software produced in Brazil;

(iv) National System of High Performance Processing (*Sistema Nacional de Processamento de Alto Desempenho - SINAPAD*), aimed at setting up a series of centers to render super computational services in the country,

they have not found the flexibility and the stability necessary for change to take place, mainly at times of changing techno-economic paradigms. Thus, it should come to no surprise that by mid-decade, problems of institutionalisation and financing were sufficient to make government agencies to change their aim with respect to the new techno-economic paradigm.

Some of these responses (such as information society - see last footnote; and the S&T sectoral funds - see last section) only came into effectiveness in the following decade. Despite these attempts to overcome institutional and financial problems regarding science, technology and innovation in general, and those initiatives specifically focused on the on-going techno-economic paradigm, they have yet to be shown effective before they can be appraised.

For this reason, the major elements to be taken into consideration in the analyses of BNSI's technological domain, will be those concerned with the availability of education, technological and training services. As for the education system, despite improvements in the number of students attending school at all levels (including post-graduate studies), its qualitative performance did not keep up to reasonable standards<sup>34</sup>.

The number of under-graduate students has increased from about 1,5 million students in the beginning of the 1990s to close to 3 million in 2000 (INEP). It is relevant to point out that the great majority of these students are enrolled in private schools of higher education. While the number of public institutions in this level of the educational system has stabilized around 200 since the 1980s, those in the private sector have increased from about 650 in 1990 to about twice that number in 2000.

As a result, the number of students enrolled in private schools is close to 75% of the total in higher education in Brazil. A closer look, though, can show two different realities with these numbers. On the one hand, they are in those areas where investment in laboratories and equipment is lower (mainly those linked to humanities). On the other, if one takes as a proxy, the figures for those school which offer courses in mechanical and electrical engineering, public schools (most of them

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<sup>34</sup> - It is important to bear in mind that over 25% percent of students attending primary school in Brazil, take seven years in order to complete the first five years of the educational system. Even more relevant is the fact that substantial number of those who finish primary education do it without proper competence on mastering reading and writing Portuguese and basic mathematics.



maintained by the federal government), responds for about 60% of total enrollment in these areas in the country.

The number of graduate courses have also increased in the 1990s. By the end of the decade there were close to 2,700 Master and PhD courses in the country. Of those, only about 300 in engineering. This low participation of engineers with research training should be looked at as an indication that one cannot expect much interaction in the BNSI of the sort that helps to codify tacit knowledge as suggested by Nonaka and Takeuchi (1995).

Moreover, emphasis should be added to the general criticism that is made to the rigidity that prevails among courses and disciplines being offered in most institutions of higher education in the BNSI. In most interviews that have been made with agents of local production arrangements (APLs), this rigidity is emphasized by academic people, policy makers, managers and entrepreneurs, as a bottleneck for closer links between higher education and society at large, and firms, more specifically.

Furthermore, the "...need for changes in the institutional framework to ensure that the long-term, creative and critical aspects of academic research can survive" [Lundvall (2002)] finds poor ground in the BNSI. Frozen wages; poor working conditions; short and unstable funding for research activities, made lecturing and researching into a very unattractive activity in Brazil throughout the 1990s. Not surprisingly in many public schools of higher education the number of 'substitute lecturers'<sup>35</sup> increased in the 1990s and reached in many faculties figures above 25%. That, by itself, increases the amount of bureaucratic work to be done by remaining faculty members which keeps them more and more distant from the classrooms and the laboratories; from creativity and criticism necessary for changing the institutional framework.

The general picture does not get much better if one moves from formal education and research into training and innovation services. Empirical work done in about 20 local productive arrangements (APL)<sup>36</sup> show that even when these services are provided by organizations specifically conceived to respond to the specificities of local SMEs, the gap between what is offered and what is used can remain big.

That is so even when one is dealing with unsophisticated technological / innovation services. In the case of the shoe making arrangement in Paraíba state, for example, remains a gap between the services that are offered by the local branch of SENAI<sup>37</sup> and the low level of demand for such services, mainly, by micro and small enterprises.

#### **4. Final comments**

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<sup>35</sup> - Can only be hired for a period which cannot exceed two years.

<sup>36</sup> - A concept derived from that of national system of innovation which has been used by a network of Brazilian researchers on the economics of innovation (*RedeSist*). See [www.ie.uftrj.br/redesist](http://www.ie.uftrj.br/redesist).

<sup>37</sup> - An agency set up by the federation of industrialists for workers training and innovation services.

The 'lost decade' debate has been present in the Brazilian agenda since the 1980s. Those were the years when the country missed opportunities (i) to re-negotiate its debt in a way different from the 'debt is not to be paid, but to be re-scheduled' approach used by pragmatic policy makers in the aftermath of the Mexican crisis in 1982; (ii) to have hyper inflation under control in 1986 when the 'Cruzado Plan' was hit in its fundamentals as price stabilization at low socio costs became a issue of life or death for politicians in the ruling party; (iii) to have a more stable and flexible institutional framework under the 1988 Constitution which became a patch work of conflicting socio, economic and political issues.

Nevertheless, many studies done about the economics of innovation in Brazil in the 1980s [among others: Evans and Tigre (1989a,b); Hobday (1990); Hewitt (1988); Pessini (1986); Schmitz and Cassiolato, eds. (1992); Tigre and Ferraz (1989); Villaschi (1992)], brought evidence that, despite all the problems in the country's macro-economic scenario, Brazil had performed fairly in many core areas of the IT techno-economic paradigm. Despite problems here and there in the informatics policy, the results in telecommunications and in other areas (banking automation, petroleum, aeronautics, for instance) signaled towards internal institutional and innovation capabilities which could help the country to put a fair stand in its run under the new techno-economic paradigm.

In the 1990s the 'lost decade' debate lost momentum as there was a next to total acceptance among government officials, that once the price stability was conquered and markets freed from regulation, the country would go back to the growth path which characterized its economy for most part of the XX Century. Price stability was won in 1994 but at a very high price for economic stability as emphasized by Coutinho (2003), among others.

This paper brings evidence that support the indication that the exaggerated cult to the market which stood at the core of economic policy in Brazil throughout the 1990s has jeopardized the country's chances for medium- and long-run economic stability. It is so because, issues which are considered as crucial if a country is to play an active role in world flows of goods, services and knowledge which matter under the ICT techno-economic paradigm, have been taken for granted.

Basic features of the 'new' TEP such as knowledge and communication linked with the human mind; information intensive production processes; production networks; knowledge intensive business services; government information, co-ordination and regulation; 'vision', among others, have been left aside in the country's public debate and in the government's agenda.

Under these circumstances, the country's insertion in the new phase of internationalization of economic and socio relations - the so-called globalization, became a matter of increasing its market share for commodities of low value-added such as soya, steel, paper pulp, shoes, etc.. It was as if the signs of what was taking place in other countries (specially OECD ones) were an abstraction which should not be paid attention to by a socio-economic formation with the natural resources endowments of continental Brazil.

The need to keep in pace with what was being discussed about learning, knowledge in an era which was not a prospect any longer, was recognized only by a very restricted

community of academic people, businesspersons, politicians and government officials. They certainly were not able to put the country in pace with what Tuomi (2001){ XE "Tuomi, I (2001), *From periphery to center: emerging research topics on knowledge society*, Helsinki: TEKES" }, calls the two waves which dominated the debate about knowledge society in the 1990s.

The first one focused on issues which were already present in the debate in the 1980s (competitiveness, economic growth, access, regulation, privacy, security, and intellectual property rights) plus the addition of the{ XE "Ducatel, K, Webster, J, and Herrmann, W (2000), 'Information infrastrures of societies?', in Ducatel, K, Webster, J, and Herrmann, W, eds. (2000), *The information society in Europe: work and life in an age of globalisation*, Lanham, ML/USA: Rowman& Littlefield" } emerging concern about information haves and have-nots.

The second wave is identified with the concerns expressed by Ducatel and his colleagues: “The relationship between technological change and social transformation is now acknowledged to be a complex one, and the simple notion of technological changes having social effects, which in turn can be simply controlled by appropriate policies, has now been shown to be false... This bring an added complexity to policy making: it is not enough to develop and implement appropriate technology policies in isolation. Technology policies and social policies have to be developed in a complementary way and strive for complementary objectives. It is necessary, if we want the ‘society’ in information society to be more than a rhetorical device, to develop a more sophisticated appreciation of these social issues.” [Ducatel et al. (2000, p 9), quoted in Tuomi(2001, p.8).

That, by itself, should be enough to justify the stands that have been taken in this paper. They are not, by any means, to be taken as if one should go into wishful thinking regarding the windows of opportunities that are open to the BNSI under the ICT TPE. Much to the contrary, what the paper tries to emphasize is along with the way Arocena and Sutz (2002) see the applicability of the n.s.i. concept in the South: "On the contrary [to what takes place in the North where the concept has been built on the basis of empirical findings], in the South it is rather an 'ex-ante' concept, because socio-economic behavior regarding innovation at national level is, in fact, hardly systemic." (ibid., page 6).

Looking form this perspective, one could say that this paper takes a stand similar to that which was taken by Freeman and Louçã (2001). They quote, Charles Dickens, in his *Tale of Two Cities*: “It was the best of times, it was the worst of times, it was the age of wisdom, it was the age of foolishness, it was the epoch of belief, it was the epoch of incredulity, it was the season of Light, it was the season of Darkness, it was the spring of hope, it was the winter of despair, we had everything before us, we had nothing before us”.

They finish their book saying that the fundamental thing is to choose. This paper has chosen to highlight issues that the Brazilian socio-economic formation must face in three autonomous and interdependent domains which can characterize a n.s.i. facing

the challenges and opportunities under the ICT TPE<sup>38</sup>. The technological domain (which makes technology available), the economic domain (which assures innovation is feasible and sustainable) and the institutional one (which makes innovation possible).

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<sup>38</sup> - As Antilla and Lemola (2003) stress these challenges and opportunities must be faced with a high degree of creative destruction if one a country is to benefit from leap frog as Finland has done. An additional challenge to Brazil, then, is to break with its last twenty years of uncreative destruction of institutional and innovative capabilities.

## References:

- Ali-Yrkkö, J (2001), *Nokia's network - gaining competitiveness from co-operation*, Helsinki: Taloustieto,
- Andersen, E and Lundvall, B-Å (1988), 'Small national systems of innovation facing technological revolutions an analytical framework', in Freeman, C and Lundvall, B-Å, eds. (1988), *Small countries facing the technological revolution*, London: Pinter,
- Antilla, P and Lemola, T (2003), 'Transformation of Innovation system in a Small Country – the Case of Finland', prepared for presentation at *GLOBELICS Conference*, Rio de Janeiro, 2-6 November, 2003,
- Arocena, R and Sutz, J (2002), 'Innovation Systems in Developing Countries', *DRUID Working Paper 2002-5*, available at <http://www.druid.dk>,
- Arrow, K (1962), 'The economic implications of learning by doing', *Review of Economic Studies*, **XXIX**(80):155-73,
- Castells, M (2000), *The information age economy, society and culture*, 2a. ed., Oxford:Blackwell,
- Campos, R, Cário, S and Nicolau, J (2003), 'Textile and clothing local productive system in the Itaji Valley: local capabilities and partial interactive learning', in Cassiolato, Lastres and Maciel, eds. (2003),
- Cassiolato, J, Lastres, H and Maciel, M, eds. (2003), *Systems of Innovation and Development - evidence from Brazil*, Cheltenham, UK: Edward Elgar,
- Cortada, J (2000), 'Progenitors of the information age - the development of chips and computers', in Chandler Jr, A e Cortada, J, eds (2000), *A nation trasformed by information*, New York::Oxford University Press,
- Coutinho, L (2003), 'Macroeconomic regimes and business strategies : an alternative industrial policy of Brazil in the wake of the 21<sup>st</sup> century', in Cassiolato, Lastres and Maciel, eds. (2003),
- de Paula, N, Porcine, G and Scaltolin, F (2003) 'Strengthening and weakening local capabilities: the case of the local innovation system in the Paraná soybean agroindustrial sector', in Cassiolato, Lastres and Maciel, eds. (2003),
- Dosi, G (1984), 'Technology and conditions of macroeconomic development', in Freeman, C, ed. (1984), *Design, innovation and long cycles in economic development*, New York: St. Martin's Press,
- Dosi, G, Freeman,C, Nelson, R, Silverberg, G e Soete, L, eds. (1988), *Technical change and economic theory*, London: Pinter,
- Ducatel, K, Webster, J, and Herrmann, W (2000), 'Information infrastres of societies?', in Ducatel, K, Webster, J, and Herrmann, W, eds. (2000), *The*

*information society in Europe - work and life in an age of globalisation*, Lanham, ML/USA:Rowman& Littlefield,

Edquist, C (2001), 'The systems of innovation approach and innovation policy an account of the state of the art', presented at *The Nelson and Winter DRUID Summer Conference*, June 12-15, 2001, Aalborg, Denmark,

Evans, P and Tigre, P (1989a), 'Estratégias de desenvolvimento de indústrias de alta tecnologia: análise comparativa da informática no Brasil e na Coréia do Sul', *Revista Brasileira de Economia*, 43(4): 549-73, FGV: Rio de Janeiro,

Evans, P and Tigre, P (1989b), 'Brasil e Coréia: para além dos Clones', *Novos Estudos CEBRAP*, 24(1): 110-130, CEBRAP: São Paulo,

Fransman, M (2002), *Telecoms in the Internet Age - from boom to bust to... ?*, Oxford: Oxford University Press,

Freeman, C (1987), *Technology policy and economic performance - lesson from Japan*, London:Frances Pinter,

Freeman, C e Louçã (2001), *As time goes by - from the Industrial Revolutions to the Information Revolution*, Oxford: Oxford University Press,

Freeman, C e Perez, C (1988), 'Structural crises of adjustment business cycles and investment behaviour', in Dosi et al., eds. (1988),

Gertler, M (2001), 'Tacit knowledge and the economic geography of context or The undefinable tacitness of being (there)', presented at *The Nelson and Winter DRUID Summer Conference*, 12-15 June, Aalborg, Denmark,

Hämäläinen, T (1999), 'A techno-economic paradigm shift and the process of socio-institutional adjustment', in Schienstock, G e Kuusi, O, eds. (1999), *Transformation towards a learning economy*, Helsinki : SITRA,

Hewit, T (1988), *Employment and skills in the electronics industry: the case of Brazil*, D. Phil. Thesis, University of Sussex,

Hobday, M (1990), *Telecommunications in Developing Countries - the challenge from Brazil*, London: Routledge,

Jaguaribe, A (1987), 'A Política Tecnológica e sua Articulação com a Política Econômica: elementos para uma análise da ação do Estado', *Texto para Discussão no. 115*, Rio de Janeiro: IEI/UFRJ,

Johnson, B and Lundvall, B-Å (2001), 'Why all this fuss about codified and tacit knowledge?', presented at *The DRUID Winter Conference*, 18-20 January, Aalborg, Denmark,

Kuusi, O (1999), 'Growing and learning entrepreneurial networks ad the focs of the national innovation strategy', in Schienstock adn Kuusi, eds. (1999),

- Lemos, C and Palhano, A (2003), 'Clustering in a backward region: the footwear productive system in Campina Grande', in Cassiolato, Lastres and Maciel, eds. (2003),
- Lemos, M, Campolina, C, Borges, F, Crocco, M and Camargo, O (2003), 'Liberalization and local innovative capabilities: the Fiat supplier network in Minas Gerais', in Cassiolato, Lastres and Maciel, eds. (2003),
- Lundvall, B (1985), *Product innovation and user-producer interaction*, Aalborg: Aalborg University Press,
- Lundvall, B (2002), 'The university in the learning economy', *DRUID Working Paper 2002-6*, available at <http://www.druid.dk>,
- Miettinen, R (2002), *National Innovation System - scientific concept of political rhetoric*, Helsinki: Edita,
- Nonaka, I e Takeuchi, H (1995), *The knowledge-creating company how Japanese companies create the dynamics of innovation*, Oxford: Oxford University Press, 18
- North, D (1991), 'Institutions', *Journal of Economic Perspectives*, **5**(1):97-112,
- Perez, C (1997), 'The social and political challenge of the present paradigm shift', presented at the *Norwegian Investorforum*, 15-16 May, Oslo, Norway,
- Perez, C and Soete, L (1988), 'Catching up in technology entry barriers and window of opportunities', in Dosi et al., eds (1988),
- Pessini, J (1986), 'A indústria brasileira de telecomunicações: uma tentativa de reinterpretação dos mercados recentes', Dissertação de Mestrado, Campinas, SP: IE/UNICAMP,
- Piragibe, C (1988), 'Electronics industry in Brazil and the role of the State: some aspects', in Piragibe, C ed. (1988), *Electronics industry in Brazil*, Brasília: MCT/CNPq,
- Polanyi, M (1958), *Personal knowledge towards a post-critical philosophy*, Londres, Routledge,
- Rosenberg, N (1976), *Perspectives on technology*, Cambridge: Cambridge University Press,
- Schienstock, G and Hämmäläinen, T (2001), *Transformation of the Finnish innovation system*, Helsinki: SITRA,
- Schmitz, H and Cassiolato, J, eds. (1992), *Hi-tech for industrial development - lessons from the Brazilian experience in electronics and automation*, London:Routledge,
- Szapiro, M (2003), 'Downgrading local capabilities in IT: the telecom innovation system in Campinas', in Cassiolato, Lastres and Maciel, eds. (2003),
- Tigre, P, Ferraz, J, coords. (1989), 'Avaliação e perspectivas tecnológicas das empresas estatais', Brasília: CNPq, mimeo,

Tuomi, I (2001), *From periphery to center: emerging research topics on knowledge society*, Helsinki: TEKES,

Vargas, M and Alievi, R (2003), 'Learning trajectories and upgrading strategies in the footwear productive system of Sinos Valley', in Cassiolato, Lastres, Maciel, eds. (2003),

Villaschi, A (1992) *The Brazilian national system of innovation opportunities and constraints for transforming technological dependency*, PhD Thesis, University of London, Birkbeck College, London,

Villaschi, A and Lima, E (2003), 'The metal-mechanic production system in Espírito Santo: commodity exports and local industrial capabilities', in Cassiolato, Lastre and Maciel, eds. (2003).