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The political economy of innovation policy - institutional weakness in Brazil at times of changing techno-economic paradigm*

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1. Introduction

This article reviews the shortcomings of science and innovation policies in Brazil, from an institutional evolutionist perspective. Based on the concept of the national innovation system (NIS) as an institutional arrangement that embraces technological research and dissemination institutes, development and financing institutions, and macroeconomic policy and coordination mechanisms, among others, it follows that positive convergence and coordination between those components of the NIS is a necessary condition for expanding national innovation capacity.

Nonetheless, positive coordination and convergence are neither natural nor autonomous processes. As the institutions do not self-organize, their evolution requires some effort that will need to be greater when the techno-economic paradigm shifts. As a result, there is no single pattern or model to follow; on the contrary, this could vary on the basis of the structure, connection, and institutional evolution of the processes of innovation capacity-building, development and technological research organizations, and macroeconomic coordination mechanisms.

In view of the foregoing, this paper considers how Brazil has adapted to the structural alterations caused by changes in the technological basis of world development, specifically looking at the case of the Research and Projects Financing Agency (FINEP), the country's leading agency for the promotion of technological innovation. In particular, the analysis will focus on fluctuations in that institution's budgets and its budgetary performance.

Created in July 1967, FINEP channels funding to enterprises, universities, and research centers involved in technology and innovation development projects, that are linked to the country's economic and social development.

The institution, which is attached to the Ministry of Science and Technology, has several lines of financing available for research into the development of new products and processes. Its main area of concern is the enhancement of Brazilian competitiveness through innovation capacity-building.

The paper is premised on the belief that the mere existence of a well designed innovation policy, even one that has stable and flexible institutions, does not necessarily guarantee positive outcomes. In fact, innovation policy may actually produce mediocre and poor results if it is inconsistent with macroeconomic policy, since the two together can help create an environment that encourages (or discourages) the search for innovations.

In Brazil empirical evidence appears to show that macroeconomic policy managers systematically fail to communicate with the makers/operators of scientific and technological policy, and make no effort to develop the positive coordination that is needed to build innovative capacity. Over time, these characteristics demonstrate

an institutional weakness in Brazil that needs to be overcome, to position the country and create conditions for progress in terms of dynamic and innovative capacity.

This article uses elements and concepts drawn from institutional economics, albeit from a standpoint that is compatible with neo-Schumpeterian evolution. From these complementary perspectives that highlight change and evolution, institutions cannot be treated merely as elements of allocative efficiency, but should be seen instead as entities that need to enter on a learning path that enables them to cope with constant change and in this context a number of institutional learning concepts are being developed.

The empirical evidence used was obtained from publications and activities reports of scientific and technological institutions and particularly FINEP's annual activities reports. Other evidence emerged from interviews held to supplement the present analysis, with FINEP officials and former directors who were directly involved in the financing/promotion of science, technology and innovation projects in the 1990s.

The paper consists of three sections in addition to the introduction. Section 2 sets out key concepts that form a theoretical frame of reference for analyzing the role played by institutions in establishing order in an economic environment characterized by radical change. It also highlights that institutions provide the framework in which agents perceive the reality around them, forming differentiated behavior patterns that will reflect, in environmental terms, on possible innovative paths. The concept of mental models is of fundamental importance here.

Section 3 describes a set of structural changes that affected the Brazilian innovation system during the 1990s, such as trade and financial liberalization, the privatization of public-sector enterprises, and the price stabilization plan. This plan introduced in the mid-1990s substantially altered the federal government's monetary and fiscal policy stance. The paper also describes how these changes affected FINEP instruments and projects, making it very difficult to promote development and channel credit to innovative activities.

The fourth section presents a number of conclusions as final comments.

2. Theoretical frame of reference

a. Institutions and institutional change in a neo-Schumpeterian perspective

The revival of institutional studies has been a major feature of recent developments in economic theory. The different methodologies used by each school of thought, however, tend to define "institutions" in ways that are nearly always non-convergent.

At times institutions are seen as concrete organizations, deliberately constructed by economic agents, with specific aims relating mainly to creating stability and

reducing transaction costs. At other times they are presented as informal arrangements that mould behavior, language, culture, habits, and routines, at the corporate or individual level. In still other approaches, institutions are portrayed as "rules of the game" (North, 1989), while some authors reject that definition as focusing only on the regulatory aspect of the institution, while neglecting its cognitive dimension (Pondé, 2005).

This proliferation of different conceptual approaches often obscures the very notion of "institutions" as used by economists — a concern that is explicitly raised in Edquist and Johnson (1997), who argue that inconsistency in the concept of institutions, or even a very broad interpretation, can hinder any understanding of the role they play in the innovation process. For these authors,

> Almost everything – at least a very large part of economic behavior and many types of economic activities and processes – can be subsumed under the concept of institutions. No wonder institutions are important! But can we really use a concept that covers so much and tries to do so many things? (Edquist and Johnson, 1997, p. 41).

This concern is reiterated in Johnson, Edquist and Lundvall (2003):

> The system of innovation approach is also associated with problems and weaknesses. For example, there is still some basic confusion regarding central concepts. One example is the term institution, which is used in different senses by different authors – some referring to social norms, such as trust, while others refer to types of organizations, such as universities (Johnson, Edquist and Lundvall, 2003, p. 6).

For Pondé (2005), however, a theory that seeks to explain how the elements of capitalism function will always entail research into the institutional mechanisms that comprise it and potentially explain its patterns of operation (Pondé, 2005, p. 138). In that case, it would be impossible to distinguish between institutionalist and noninstitutionalist, even if institutions are not chosen as the central focus of analysis.

Neo-Schumpeterians incorporate analysis of institutions as influencing structural change in an economic system (Freeman, 1995; Villaschi, 1996, 2004 and 2005; Perez, 2004; Grassi, 2002). According to that school of thought, visualizing economic growth separately from the influence of institutions and the institutional apparatus that informs it, is to divest the concept of theoretical and analytical depth (Conceição, 2001, p. 15).

It is in that sense that the techno-economic paradigm needs to be understood (Freeman and Perez, 1988). That concept, which is the most detailed way of incorporating institutions into the radical change movement, seeks also to construct a theoretical framework to explain development paths, taking account of the capital accumulation regime, and the technological framework and its paths, set always in the social, political, and institutional environment (in its various dimensions) that

prevails in a given historical period (Edquist and Johnson, 1997; Conceição, 2002; Perez, 2004, and Villaschi, 2004).

The analysis of institutions thus becomes a necessary condition for progress in developing a theoretical explanation of reality. While, for evolutionists, institutions are not central objects of analysis — as they are for the institutionalist schools — they are nonetheless inseparable elements of the dynamic process of growth and technological change.

However, there is little to be gained from creating a single concept of institutions, because certain key elements, such as "regularity of behavior" and "structure" of some kind are always present, even in a broad spectrum of definitions. In fact, those different definitions reflect the fact that the institutional aspects of a capitalist economy can be analyzed on different levels (Pondé, 2005).

Nonetheless, a belief is emerging that institutions cannot be defined merely as organizations, laws, customs, routines, habits, traditions, or rules of the game. In other words, they cannot be seen merely as mechanisms designed by man that place restrictions on behavioral freedom and shape human interactions. Regulation is just one of the dimensions of institutions (Pondé, 2005). The regulatory aspect can be defined as social processes whereby rules of behavior are established, their observance monitored, and sanctions applied — as rewards or punishments — with a view to influencing conduct in specific directions (Scott, 1995, p. 35, quoted in Pondé, 2005). Such processes can be formal or informal.

Many of the contributions made by economic theory to the study of institutional mechanisms in the capitalist system[1] focus on this dimension of institutions. This clearly reflects the assumption of some form of rationality underlying the behavior of economic agents, in terms of seeking regularities, security in the face of uncertainty, or private benefit of some kind (North, 1989 and 2003; Conceição 2001 and 2002).

More recently, a number of theoretical developments have begun to focus on another dimension of institutions, namely the cognitive, which unlike the regulatory aspect, represents the ways in which the nature of reality is established and the structure through which meanings are produced (Scott, 1995, p. 40, quoted in Pondé, 2005). This dimension of institutions is linked to the symbolic forms through which individuals perceive and interpret events and the natural and social world around them.

According to neo-Schumpeterian theory, this is a fundamental aspect of institutions since they mould perceptions and reaction to stimuli, and shape the approach to

[1] Institutionalist theories, in all of their different guises, always assume a capitalist production system, since they always start from the existence of private property and the production of goods and services governed by market-mediated transactions. In other words, the fundamental institutions of capitalism are taken as given.

seeking solutions. They also shape individual conduct, the various forms of interaction and, fundamentally, learning possibilities in all their forms, thereby affecting both the direction and the flow of innovations. The concept of "mental models", developed by several authors including Perez, (2004), Dosi (2003), Seri (2003) and (Kim, 1993), North and Denzau (2003, p. 2), is very closely linked to this cognitive aspect of institutions.

Institutions in their regulatory dimension are thus external mechanisms that impose order on an environment characterized by a number of different mental models, which themselves represent institutions in their cognitive dimension. These issues will be addressed in part c of this section.

According to Villaschi (1996 and 2004), the notion of techno-economic paradigm, developed by Freeman and Perez (1988) centers on a broader interpretation of the creative destruction process of Marx and Schumpeter (Villaschi, 2004, p. 02). Nonetheless, "changes in the techno-economic paradigms not only change the engineering trajectories for specific product or process technologies but require fundamental adjustments in organizational and socio-institutional arrangements of society" (Hämäläinen, 2003, p. 37). As Perez (1983) points out, a period of paradigm shift implies a change in the nature of the environment in which agents operate, since a new growth model is being inaugurated whose characteristics are previously unknown. Such a period is marked by crises because institutional changes lag behind radical technical innovations. Once again, as Perez (2004) points out, "even when the need for change is understood, social institutions and the general framework of socioeconomic regulation have a natural inertia, partly as the result of past successes, partly due to vested interests" (Perez, 2004, p. 16).

In that sense, paradigm shifts demand far-reaching changes in institutions, in both their regulatory and their cognitive dimensions, because new products, new industries, new markets, and new processes cannot be fitted into old regulatory mechanisms. Paradigm shifts also require new ways of constructing meaning, new ways of conceiving the content and nature of the changed environment.

At times of paradigm shift, traces of the old paradigm coexist with the new one. This makes institutions crucial both in terms of flexibility, in the sense of allowing adaptation to the new, and in terms of stability, in the sense of maintaining a relative order that allows material reproduction to continue, with some consistency, even in the midst of radical change (Villaschi, 1996, 2004, and 2005).

This flexibility/stability duality is of fundamental importance: very rapid institutional change can spawn poorly designed institutions with no capacity to provide support in conflictive times. On the other hand, institutional rigidity can seriously hinder the forging of new paths and new opportunities, creating the possibility of lock-in. Thus, to use the notion of Freeman and Perez, relative inflexibility in the institutional apparatus can slow the rate of innovation, if the adaptations needed for the establishment and potential of the new paradigm fail to occur (Bueno, 1996). In times of transition such as these, the economic system will create and operate in a

crisis dynamic (Villaschi, 2004), until socioinstitutional adjustments (both regulatory and cognitive) are in place.

It is thus not hard to see that the growth process flows basically from the institutional arrangement, from its mechanisms, and from its modes of promoting interaction, because: (a) it allows for fundamental changes to be made, as required in times of paradigm shift; (b) it creates, influences, and makes viable technological innovations; (c) it coordinates the necessary convergence between growth and development;[2] (d) it affects the way reality is perceived, the patterns by which solutions to problems are constructed and expectations formed, and hence the way decisions are made by economic agents; and (e) it imposes different patterns of reaction to stimuli, encouraging or discouraging the search for ways to construct innovation capacity.

Nonetheless, institutions do not guarantee growth and are not perfectly adaptable to a changed environment, since they cannot be understood as mechanisms for optimizing allocative efficiency, but [...] as part of a dynamic, continuous, and relatively uncertain process, inseparable from technological and social changes (Conceição, 2001, p. 153). This idea is also clear in the thinking of Hodgson (2001), who stresses that there are no intrinsic mechanisms for error correction or self-discipline along the paths of institutional change; in other words, the system operates without self adjustment tools.[3] This raises the possibility of the existence of inadequate institutions, or what Edquist and Johnson (1997) refer to as "institutional sclerosis", or "cumulative deterioration" as described in Veblen (1983).

For Pondé (1994), all operations and activities in a market need to be organized within a structure that is continuously being revolutionized from within. But such organization and revolution also need to be constantly legitimized. It is institutions that have to play these two roles. These institutional functions, however, are seriously hindered by the fact that institutional innovations tend to be just incremental, whereas technical and economic innovations are radical (Hämäläinen, 2003).

b. National innovation system (NIS)

The national innovation system (NIS) concept arises from the work of Freeman and Lundvall. It can be understood as representing the complex institutional arrangements that exist at different levels and their mechanisms of interaction, including beyond the country's geographic borders, which, directly or indirectly, influence the path and development of a nation's innovation capacity, either pushing it forward or holding it back (Villaschi, 1996, 2004, 2005). From this

[2] For the purposes of this study, development is understood as the parallel construction of conditions needed to make the growth process itself sustainable, when this occurs.

[3] This is a line of thought that is contrary to the new institutional economics (NEI), which sees institutions as a tool for increasing efficiency, imposing order on the system, and reducing transaction costs.

standpoint, the NIS must always be seen in institutional terms (Edquist and Johnson, 1997).

Times of paradigm shift pose major challenges to the NIS because the nature of institutions and their current interaction mechanisms are being transformed, and they might no longer be the best way to respond adequately to the challenges and radical changes that are under way. Thus, the capacity of a country to exploit the "windows of opportunity" that appear, depends crucially on its ability to mobilize political, financial, and economic resources to implement structural changes in economic and institutional terms, to make the arrangements comprising the NIS compatible with the characteristics of the new paradigm (Villaschi, 2005).

According to Villaschi (2003 and 2005), the mobilization needed to construct collective solutions requires a major effort, since the content, nature, and direction of the forces capable of promoting such changes and mobilizations, in the different domains and institutions that make up an NIS, are neither uniform nor always convergent. As Perez (2004) aptly notes, the different institutional levels, or the subsystems in the NIS, perceive necessary changes and increase the pace of such changes at highly differentiated speeds. Unless these are enhanced, the system will not operate at full capacity (Hämäläinen, 2003; Villaschi, 2004 and 2005; Perez, 2004).

Given the complexity of such changes, which engage not only economic variables, but also social, political, and even religious ones, the model for constructing solutions cannot be implemented by individual agents in isolation. The catch-up process can only be guaranteed if collective solutions are constructed. (VILLASCHI, 1996).

Apart from such complexities, the NIS concept is not easy to apply to developing countries (Lundvall et al, 2002). As these authors put it,

> When applied to countries in the South it is important to be aware of some weaknesses of the innovation system approach, as it has been used so far. Some of these have directly to do with the fact that it has mostly been applied to the North. [...] . It has been used to describe, analyze and compare relatively strong and diversified systems with well developed institutional and infrastructure support of innovation activities. It has not, to the same extent, been applied to system building. When applied to the South the focus ought to be shifted in the direction of system construction and system promotion (Lundvall, et all, 2002, p. 226).

c. Mental models and cognitive spaces: from individual to institutional learning.

The methodology of economic analysis under rational expectations assumes that agents' behavior is guided by substantive rationality. This is the type of behavior present in the neoclassical models, where individuals use all available information and always correctly predict the future behavior of significant variables. In this case, "optimal choice" and equilibrium are guaranteed because, first all individuals are assumed capable of manipulating a complex econometric model, and second the interpretation of available information is convergent (Ferrari, 2001).

In the analytical method that uses adaptive expectations, individuals adjust their current expectations so as to correct prediction errors committed in previous periods. In this case, rationality is also adaptive, because achieving the optimal choice ceases to be an instantaneous action and becomes a process (i.e. constructed through intuitive interpretations of past errors).

Assuming the existence of substantive rationality means assuming that individuals share the same mental model. That is they interpret available information in similar ways and take the same decisions based on convergent expectations concerning the environment in which they operate. In the case of adaptive expectations, agents, while erring, learn from identical interpretations of past errors. This means that they all learn in exactly the same way, at the same speed, and along the same lines. So, here too, adaptive expectations assumes the same mental model for all economic agents.

Heterodox interpretations of the economy reject those two possibilities. Instead, they assume a "bounded rationality", a concept developed by H. Simon (1962), which means that economic agents face constraints on their capacity to consider and process all the information needed for decision making, and therefore cannot know all alternative possibilities.

Although much has been written on this subject, few studies consider the fact that this rationality constraint cannot be the same for all agents, since it would require all individuals to have the same mental model, which is highly questionable. On the contrary, one should assume the existence of several different mental models, which means several different forms of bounded rationality. [4]

Seri (2003) sees the concept of mental models as a fundamental tool for the evolutionary theory of economics, since it gives differentiated shape and content to the existence of bounded rationality.

According to North and Denzau (2003), "the mental models are the internal representations that individual cognitive systems create to interpret the environment and the institutions are the external (to the mind) mechanisms individuals create to structure and order the environment"[5] (North and Denzau,

[4] According to Sbicca and Fernandes (2005), for Simon, the information held by the economic agent on his or her environment is much less than an approximation of the real situation. The perceived world is very different from the "real" world, and this difference involves omissions and distortions that arise from differentiated perceptions and inferences made by agents. Thus, decision models only deal with a small fraction of all the relevant characteristics of the real world. Simon claims therefore that people cannot understand the world as an integral system, but only have partial models that differ from one agent to another. The aggregation of individual behaviors with limited rationality requires new studies on the interaction between such individuals.

[5] North and Denzau (2003) see a necessary link between mental models, ideologies, and institutions: "The sharing of mental models is enabled by communication, and communication allows the creation of ideologies and institutions in a co-evolutionary process. How do mental models, institutions and ideologies interact to shape choices and the outcomes that determine political and economic performance? Mental models, institutions and ideologies are all a part of the process by which human beings interpret and order

2003, p. 4). For these authors, in conditions of uncertainty, individual interpretations of the environment in which they operate will decisively reflect their learning capacity. Accordingly, problems relating to economic policy, growth, and development, and, even economic history, require an understanding of the structures through which mental models are created and changed, since these, ultimately, are the instruments that guide the choices made by economic agents (Seri, 2003).

Evolutionary neo-Schumpeterian literature places major emphasis on the influence that learning, in all its forms (by doing, by using, by interacting), exerts on the capacity and ability to innovate, in an environment characterized by uncertainty and complexity. Mental models thus become essential tools for gaining a deeper understanding of how agents learn, without making the substantive or adaptive rationality assumptions that permeate orthodox models.

The starting point should be the following questions: How do individuals learn? What are the processes and mechanisms through which individual learning is transferred to organizations or institutions? If mental models are constructed on the basis of individual experiences, how should one understand collective behavior? How does the process of change or rigidity in mental models operate at times of paradigm shift?

From this standpoint, individual and collective learning becomes a fundamental requirement. According to North and Denzau (2003), Seri (2003), and Kim (1993), learning is a process involving responses to stimuli and changes in the external environment. Individual learning is thus a combination of processes in which the individual has a concrete experience (stimulus), makes observations and reflects on them; forms abstract concepts and generalizations; and, lastly, tests new ideas and new forms of perception in concrete attitudes, thereby creating new experiences that feed back into the flow.

In this case, learning can be divided into an operational part (linked to concrete experiences and the testing of new concepts and new applications), and a conception part (linked to cognitive structures that allow observation, reflection, and the formation of new concepts). Mental models can thus be understood as the cognitive structure that perceives those observations, interprets them, reflects on them through mechanisms shaped by past experiences, and forms expectations that will affect the formation of the pattern of attitudes that are materialized through the practical testing of new concepts. This essential linkage between mental models and individual learning is crucial to the conclusion that "learning can thus be defined as increasing one's capacity to take effective action" (Kim, 1993, p. 38).

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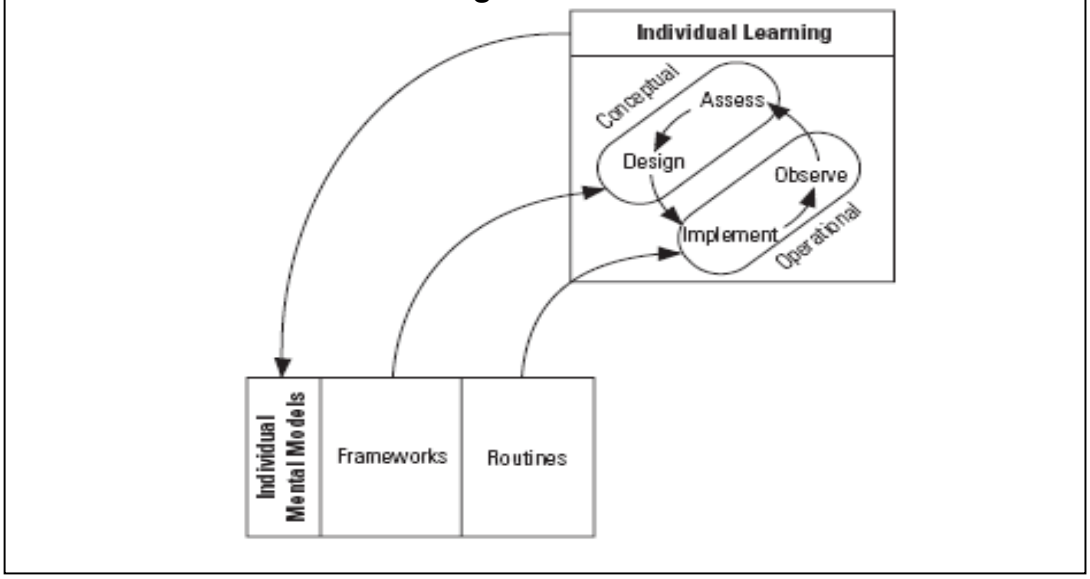
the environment. Mental models are, to some degree, unique to each individual. Ideologies and institutions are created and provide more closely shared perceptions and ordering of the environment. The connection between mental models and both ideologies and institutions crucially depends on the product and process of representational redescription" (North and Denzau, 2003, p. 5).

This idea can be represented as follows:

Figure 1
Learning and mental models



Source: Adapted from Kim (1993)

The concepts of learning by doing, learning by using, and learning by interacting can therefore only be considered effective learning if, by changing the way individuals observe and perceive reality, they increase their capacity to act on a constantly changing environment, and elicit differentiated practices.

The learning process can be characterized in two ways. First, radical learning occurs when the structure of the mental model and cognitive spaces themselves are altered. This means a totally new and differentiated way of capturing and interpreting external stimuli, which involves decision-making and concrete experiences that differ radically from previous ones. This type of learning requires a change in the currently prevailing institutional structure.

In contrast, incremental learning can be understood as maintaining the structures of the mental model and cognitive spaces, while merely changing certain interpretations of perceived signals, thereby resulting in concrete decision-making which, while differentiated, does not require any alteration in organizational forms or in institutional arrangements to be accommodated.

Taking advantage of the windows of opportunity that open at times of paradigm shift requires special adaptive changes (Hämäläinen, 2003). Incremental learning may not be best suited to such moments, since institutions remain shaped by the characteristics of the previous paradigm.

If, in those terms, individual learning involves complex relations, the degree of complexity is greater in the case of institutional learning. Perez (1983 and 2004) argues that institutions display an inertia that prevents the adaptations needed in the institutional arrangement from keeping pace with technical changes. This point of view is also shared by Villaschi (1996, 2004, and 2005) and Hämäläinen (2003). If individual learning is feasible, and given that the behavior of institutions depends, ultimately, on collective behavior, how can such learning be transferred from the individual level to the institutional arrangement?

In institutional terms, the learning process can be understood as an increase in capacity to build collective decisions that are consistent with the evolutionary environment, and which are materialized on the basis of an improvement in the quality of interaction and cooperation between all components, leading to a higher level of efficiency in the system as a whole.

Three important points emerge from the concept proposed above. First, the institutional learning process cannot take place without individual learning; institutions or organizations can ultimately only learn through individuals (Kim, 2003). Second, as Brabant (1997) aptly puts it, individual learning is a necessary, but not sufficient, condition for institutional learning, since institutional learning, as described above, involves the system as a whole. This means that one cannot conceive of institutional learning without all institutions comprising the system also learning. Third, institutional changes do not necessarily mean institutional learning, because the existence of path dependence and the need for adaptive changes can cause the system to make an alteration that is not necessarily an improvement in terms of the interactive efficiency of the arrangement as a whole.

To conclude, it should be noted that institutions can survive for a long time without learning, because, unlike market-based enterprises, the penalties for nonlearning only appear considerably later, which reinforces the idea of behavioral inertia of institutions proposed by Perez (2004).

3. Scientific, technological, and innovation policies: Considerations on the Brazilian case and FINEP.

The science and technology system in Brazil has a large and complex structure encompassing various government agencies, such as the Research and Projects Financing Agency (FINEP), the National Council for Technological Research and Development (CNPq), and Coordination of Personnel Training (CAPES),[6] with the Ministry of Science and Technology (MCT) holding the main responsibility for coordinating the country's science, technology, and innovation policies. The system also includes public and private universities, federal government research centers and state research agencies, the most important example of which is the State of São Paulo Research Foundation (FAPESP). The National Bank for

[6] Unlike FINEP and CNPq, CAPES is attached to the Ministry of Education.

Economic and Social Development (BNDES), which acts alongside this structure and is mostly involved in venture capital financing, also plays an important role.

The 1990s and the first few years of the new millennium marked an intense period of changes both for the science and technology system and for the Brazilian economy as a whole. Some of these changes resulted in fundamental successes and benefits while others imposed major constraints on the country's growth which have not yet been fully overcome.

The 1990s can be seen as the start of a process of structural change, based, among other things, on the new industrial and foreign trade policy implemented during the short-lived Collor government (1990-1992), which forcefully signaled a new way to approach the issue of innovation, productivity, and quality in the country. Nonetheless, neither the Collor government nor its successors implemented a specific and planned policy, deliberately aimed at combining the forces needed to launch the country on to another level of action, by keeping pace with international changes that were unfolding, mainly in terms of paradigm shift.

Thus, "the main policies adopted in Brazil [...], during the 1990s, reflect among other things, also a very poor understanding of the nature of the present transformations of the world economy" (Lastres, 2003, p. 3). and: "most change that took place in its institutional and economic set-up (privatization, liberalization, change of ownership of major enterprises from local to foreign firms) 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" (Villaschi, 2003, p. 2).

Using the theoretical framework discussed above, these changes will be analyzed from the standpoint of the institutions that promote the development of innovative capacity in Brazil's NIS, focusing the analysis on the FINEP.

Created in the 1960s, FINEP is a public enterprise attached to the Ministry of Science and Technology, and is one of the federal government's main means of supporting and financing investments in innovation, through R&D by national firms universities or research centers. Using either its own resources, or those provided by the National Fund for Scientific and Technological Development (FNDCT),[7]

[7] The National Fund for Scientific and Technological Development (FNDCT) was created in 1969 and has been managed by FINEP since 1971. The Fund provides the main financial support for human resource training and for basic, applied, and innovation research projects in all areas of knowledge at universities, research centers, or domestic enterprises. Generally speaking, the history of the Fund can be divided into three long periods. The first, which covers the whole of the 1970s, was characterized by stable resources, which made it possible for the FNDCT to play a special role in the institutionalization of Brazilian scientific and technological research: firstly, because it was the key financial instrument underpinning the significant growth of postgraduate courses in Brazil (both masters and doctorate courses); and secondly, because it was decisive for financing and investment in projects involving the development and improvement of technologies and processes among domestic firms, through Support for the Technological Development of National Enterprise (ADTEN). The FNDCT also played an important role in channeling resources to other agencies and bodies linked to education, science, and technology (CNPq and CAPES), and to entities linked

which was also created in the 1960s, FINEP provides support for research projects that aim to create technologically-based and innovative solutions.

As a result of its management of a fund that had stable and growing endowments in the 1970s, FINEP gained status and prestige in financing and support for innovation projects in Brazil. As it was also in this decade that Brazil consolidated its industrial structure, the role played by FINEP in channeling resources to research and innovation was crucial for the development of domestic industry (Guimarães, 1995). The ensuing decades were marked by crises, however.

With the decline in resources available for the Fund, FINEP also slid into a process of institutional crisis and spent the whole of the 1980s restructuring as a result of the complicated scenario that prevailed throughout that decade (FINEP, 1990). During this period, the Science and Technology Development Support Program (PADCT) was created to strengthen actions in scientific and technological research. This received financing from the World Bank, with counterpart funding from the Brazilian government.

Because of a lack of managerial infrastructure in the PADCT, compounded by the Brazilian government's difficulty in fulfilling its share of funding, projects that required PADCT financing took on average 360 days to gain approval, which significantly undermined their viability. As a result, this program model was weak in the 1990s (STEMMER, 1995).

Challenged by the changes, crises, and recurrent conditioning of resources that were features of the 1990s, FINEP spent most of that decade, firstly seeking new organizational, administrative and financial restructurings that could reliably sustain it without the wide fluctuations in funding from the federal budget, and secondly forming partnerships with other institutions such as BNDES and SEBRAE,[8] as well as agreements with research centers to develop specific projects in selected sectors.[9]

The structural changes of the 1990s can be considered in three different, albeit interdependent dimensions: the first linked to the process of trade liberalization; the

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to business projects (BNDES). The second period encompasses the whole of the 1980s and was fundamentally marked by a significant reduction in available resources, reflecting the diminished importance of the science and technology sector in government policies. The fact that the Fund's scarce resources were scattered among projects of minor importance led to an interpretation that the Fund had been downgraded. This period saw a decline in the prestige of FINEP, which caused the government's technical team to question the value of maintaining the Fund. The third period, the 1990s, was also marked by resource instability. The situation only changed at the end of the decade thanks to resources contributed by sector funds that would enable the FNDCT to resume its place in the structure of support for innovation and science and technology activities in Brazil. For further details on the history of the FNDCT, see for example Pacheco (2003), Guimarães (1995), Erber (1988), and Schwartzman et al (1995).

[8] The Brazilian Microenterprise and Small Business Support Service.

[9] Programs and projects for development in specific sectors, including the details of each agreement, can be found at http://www.finep.gov.br/programas/programas_ini.asp.

second related to the privatization of State enterprises; and the third linked to the price stabilization program, which involved tight fiscal and monetary constraints.

3.1 Trade liberalization in the early 1990s

The economy's opening up to international trade represented a major structural change in Brazilian industry and had profound impacts that lasted throughout the 1990s (Silber, 2003). The orientation of government policy, based on measures to increase competition, began to clearly prioritize programs that sought to promote or increase efficiency and raise productivity among domestic enterprises.

The interviews held revealed that the new way of conceiving competitiveness, essentially as a systemic factor encompassing all economic, social, and educational dimensions, in which innovation acts as the "engine of development," also influences development institutions, which start to follow that orientation even in the midst of severe crises. It is also clear that FINEP became an important ally of that government policy, by providing finance (either through interest-bearing loans or as a sinking fund) for modernization projects and for the implementation of quality management systems, especially those involving dissemination of new management practices within firms.[10] One of the key studies on competitiveness conditions in Brazilian industry[11] emerged from this conception and was contracted by FINEP, as a result of the Brazilian Quality and Productivity Program (PBQP).

On the other hand, trade liberalization also created conditions for deep crisis among Brazilian entrepreneurs, who saw foreign corporations and products gradually penetrating a market that had previously been dominated by domestic firms. Here one can clearly see a structural realignment of local capital in Brazilian industry, which was confined to low-value added sectors, as described in Villaschi (2003 and 2005).

Thus, while the opening up of the Brazilian economy considerably increased the total amount of foreign direct investment in the country, which stood at US$30 billion in 1999 compared to US$2 billion in 1994 (ERBER, 1994), this did not mean that knowledge-intensive activities also moved into the country.

What happened was a relative increase in imported products and foreign producers in industry, at a time when domestic capital displayed major competitive weaknesses, such as scant cooperation between firms, low technological capacity, little innovation effort in products or processes, and precarious participation in the international economy (Pacheco, 2003; Markwald, 2005).

It should be noted that trade liberalization was not accompanied by a specific technological development program. In other words, there was notable lack of

[10] FINEP Activities Report, various years.

[11] Coutinho, L; Ferraz, J. C. *Estudo da Competitividade da Industria Brasileira*, Campinas-SP: Papirus, 1994.

coordination between trade, industry, and science and technology policies, and no clear policy to encourage innovation (Pacheco, 2003).

Although the federal government had signaled that it would grant tax breaks to encourage R&D in firms (Law 8661/93), the requirements of fiscal adjustment meant that the benefit was substantially reduced in 1997. The results of interviews also revealed that, while the FINPE could perceive the process of change, it had neither the conditions nor the tools to counterbalance the negative impacts that it was suffering — behavior that is characteristic of institutional inertia.

Institutional reflection on that rapid structural change shows that the content and direction of the forces acting within the Brazilian NIS altered, requiring a new attitude from institutions and their interaction mechanisms. Nonetheless, as their stakeholders could not rely on new funding or new instruments, the institutional learning capacity of the Brazilian NIS was seriously compromised.

Apart from this, the variety of ways of thinking about innovation within the Brazilian NIS, and conflicts between the different mental models, some of which were closed to new forms of learning, rendered unsuitable instruments that were conceived in terms of the previous paradigm. Even among development agents, ways of thinking about solutions were neither collective nor convergent. In other words, the Brazilian institutional framework was neither flexible enough to allow a new phase of action to begin, nor sufficiently stable to support national capital at that time.

3.2 The privatization of state enterprises

The privatization process among State enterprises also constituted a major structural change, since such firms represented a considerable share of the R&D structure in Brazil in the early 1990s, and were responsible for the much of the demand for industrialized products in the country. Once privatized, those firms substantially altered their relationship with local entrepreneurs, by switching part of their demand to international suppliers.

This mainly became clear in sectors linked to information and communication technologies (ICTs). Accordingly, the privatization of public-sector enterprises would to some extent deepen the crisis that was afflicting domestic industry as a result of trade liberalization (Pêgo Filho et al, 1999). Interviews revealed that this impact was felt in particular by domestic firms that acted as suppliers to State enterprises, most of which were regular clients of research and innovation agencies.

It should be noted that privatization in sectors linked to the ICT paradigm did not improve the structure of R&D among those technologies in Brazil, because the research centers were maintained in the privatized firms' parent companies. As cumulative knowledge and learning tend to remain essentially localized, Brazil

became a field for commercial exploitation of new technologies, without progress in terms of learning being captured by the Brazilian NIS.

In other words, while privatization changed the face of the ICT system in Brazil, it would have an extremely negative impact on the country's capacity to exploit the windows of opportunity that open at times of paradigm shift. This model increased Brazil's dependency in sectors linked to the ICT paradigm. Remittances abroad resulting from technology transfer contracts rose from US$160 million in 1992 to US$1.582 billion in 2002 (MCT, 2004).

3.3 Price stabilization: the Real Plan

The third aspect of those changes relates to the price stability policy implemented through the Real Plan in the mid-1990s. Despite its major impact in terms of the "foreignization" of Brazilian production, the trade and industrial liberalization discussed above constituted an important tool for stabilizing prices through increased imports, which were sucked in by the extremely overvalued exchange rate maintained from 1994 to 1999.

Inflation, which had been 5.154% between June 1993 and June 1994, averaged 7% from 1995 to 1999 (Erber, 2003). Following the exchange-rate devaluation of 1999, success in controlling inflation was tied to two tools which, in parallel, imposed severe restraints on the country's development capacity.

The first of these was a very restrictive monetary policy, maintained through high domestic interest rates; and the other involved extreme fiscal tightening, by running a large primary surplus. This entailed a substantial reduction in state investment, particularly in infrastructure (notably transport and energy; and, most decisively, that aimed at raising the innovative, scientific and technological capacity of the Brazilian NIS. Expenditure by the federal government on R&D as a proportion of net current revenue fell from 2.4% in 1996 to 1.49% in 2002 (MCT, 2004).

Paradoxically, while studies financed by the Ministry of Science and Technology in the 1990s signaled the need for explicit investments in the most modern sectors, such as those linked to ICTs, biotechnology and chemical engineering, the economic area of the government was imposing deep investment cuts, which generated major financing crises for research and development in these sectors (Schwartzman, S. et al. (1995), Guimarães (1995) and Pacheco (2003).

This situation created an overt contradiction within the government, between the economic and technology-innovation areas. This volatility and uncertainty over funding has caused major fluctuations in investment in infrastructure for science and technology in Brazil since the 1980s, as evident in figure 1.

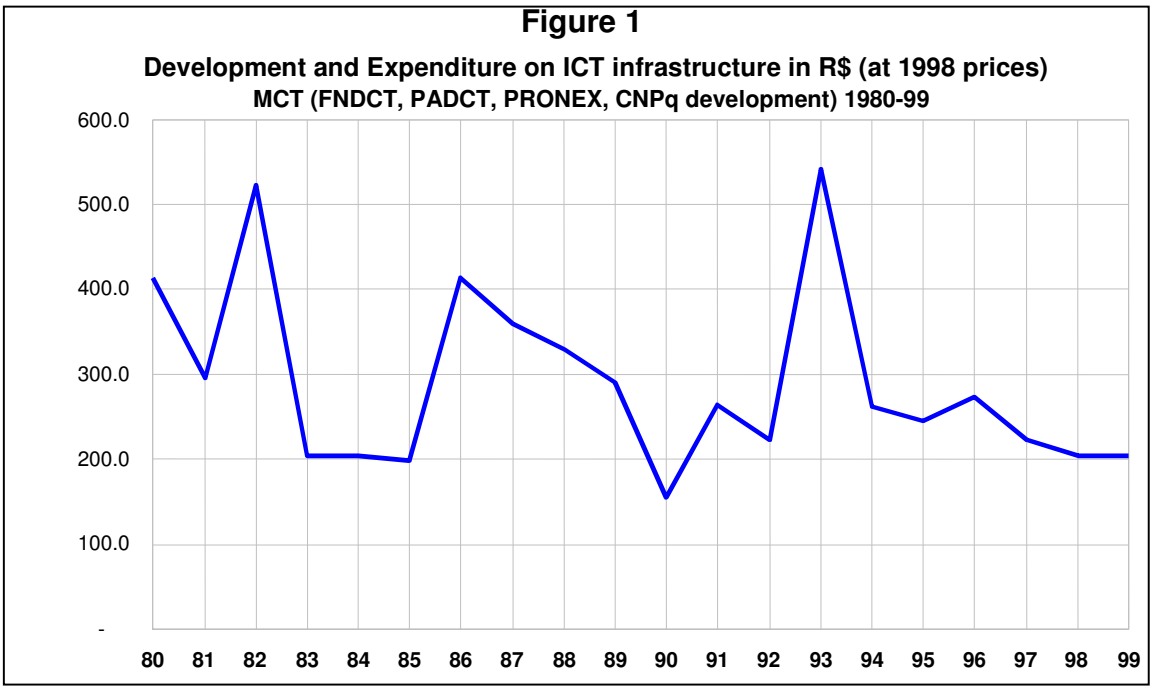
FINEP, the executive Secretariat of FNDCT, would be directly impacted by the government fiscal crisis that had lasted since the 1980s. Transfers received by the FNDCT, which were on the order of US$243 million in 1975, averaged U$62 million

in 1983-1985, before dropping to US$40 million in the early 1990s (Guimarães, 1995). The average value of FNDCT loan operations fell from US$3.72 million in 1970 to just US$80,000 in 1990[12] (Guimarães, 1995). This crisis in FNDCT funding prospects for development (non-reimbursable) and credit (reimbursable) characterized much of the 1990s.

In 1997, a search began for other sources to finance and promote R&D, based on the design and creation of sector funds (FINEP, 2000). These funds are financed by mandatory investment of a percentage of enterprise revenues in specific sectors — in some cases resulting from the exploitation of natural resources, in others from activities operated by the private sector through concession contracts.

According to Pacheco (2003), their origin dates back, firstly, to the privatization of segments of the state public sector; and secondly, to the genuine need to systematically reform the financing of science and technology activities in Brazil (Pacheco, 2003, p.11).[13] Sector funds are clearly another way to envisage financing for the development of innovative capacity. The creation of such funds represents learning in terms of an understanding that investment in innovation is critical for constructing the conditions needed for the country's development.

Figure 1



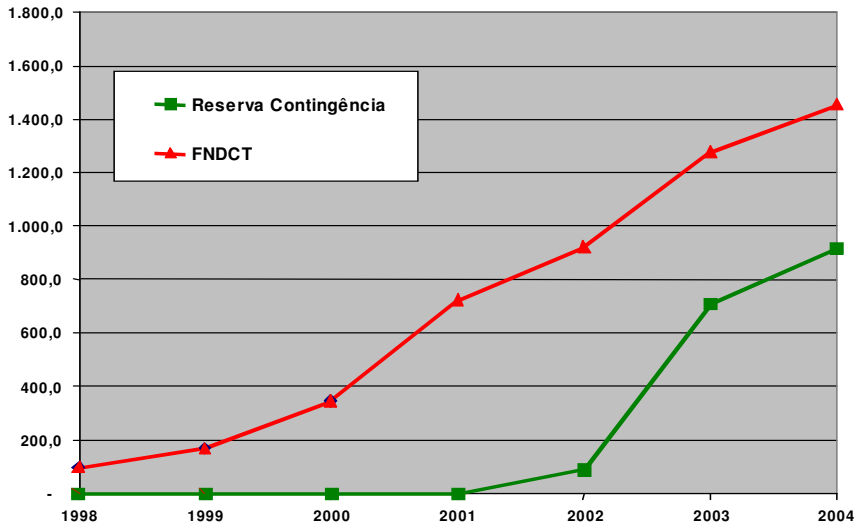
SOURCE: Pacheco (2003)

[12] Nominal values were converted to United States dollars and subsequently deflated (Guimarães, 1995).

[13] The text quoted gives details of the creation of various sector funds.

As a result, FINEP, as executing agency of FNDCT to which resources are channeled from the sector fund, has a new tool available for financing research in science, technology, and innovation in Brazil, which was immediately reflected in its budget. Amounts disbursed to the FNDCT, which had been on the order of R$39 million in 1999, rose to R$700 million in 2001 (FINEP, 2002). The receipt of sector funds would prove to be an extremely important instrument for development of the country's scientific, technological, and innovative research capacity. Figure 02 shows the trend of these receipts.

Figure 2
FNDCT and budgets, 1998-2004
Global budget and contingency reserve
(current R$)



Source: Adapted from Pacheco (2003).

The figure also illustrates the "contingency reserve" modality, which was an expenditure restriction created by the economic team to fulfill the primary surplus targets resulting from the burden of fiscal adjustment that has dogged successive federal governments ever since 1994. As Pacheco (2003) argues, "the percentage of fund revenues that were actually spent was on the order of 50% in the initial years of the operation, and now has fallen to below 40%" (Pacheco, 2003, p. 24).

This impasse heightens the contradiction between, on the one hand, investment needs in science, technology, and innovation in Brazil, and the effort to create new revenue sources to stabilize the budgets of development institutions; and, on the other hand, the extremely austere fiscal policy that has provided the "backdrop" to a performance which, even if achieved, would still fall short of requirements.

Table 1 illustrates the major impact of the austerity policy on the execution of FNDCT funding, and clearly shows that the effectiveness of new instruments created is undermined by fiscal constraints and the way disputes over the Union budget are resolved. Although the creation of sector funds has represented a significant advance for the country's science and technology sector, the imposition of fiscal adjustment policies on other areas is a major hindrance to the management of research in the Brazilian NIS.

This strengthens the argument that institutional learning cannot be considered in terms of evolution by one or other actor in the NIS in isolation. Although a change in the attitude of institutions linked to science and technology and innovation in Brazil can clearly be perceived, in others, related to monetary and fiscal policy management, attitudes remain extremely rigid, with no movement on specific actions that would make the development of innovative capacity in Brazil an essential and even urgent factor.

Table 1
FNDCT, 1998 - 2004
Budgets, contingency reserve, amounts pledged and provisioned (millions of current R$)

	1,998	1,999	2,000	2,001	2,002	2,003	2,004
FNDCT	97.9	171.4	348.2	725.0	923.9	1,278.6	1,455.7
Budget (law + credit)	97.9	171.4	348.2	725.0	921.4	683.3	619.9
Contingency reserve	-	-	-	-	2.5	595.3	835.8
Pledged	55.5	92.7	176.3	372.1	331.0	492.0	446.3
Provisioned	42.4	78.6	172.0	352.9	593.0	786.6	1,009.3
Percentages of total							
Pledged	56.7%	54.1%	50.6%	43.6%	36.0%	38.3%	32.3%
Contingency reserve	0.0%	0.0%	0.0%	0.0%	7.6%	46.6%	54.8%
Provisioned	43.3%	45.9%	49.4%	56.4%	64.0%	61.7%	67.7%

Note: Until 2002, amount effectively spent (SIAFI -National Congress);
scenario of 2003 and 2004, partial execution of the budget limit (LDO).

Source: Adapted from Pacheco (2003).

4. Final comments

The structural changes that occurred in the Brazilian economy in the 1990s ushered in a period of crises that buffeted the country's business sector. Trade liberalization and the privatization of public-sector enterprises, on the domestic front, together with radical changes in the global economy arising from installation and consolidation of the ICT techno-economic paradigm, raised an urgent need for productive modernization and improvement in the organizational performance of Brazilian industry, particularly in terms of greater innovative capacity. That complexity and the pace of change called the institutional configurations of the Brazilian NIS into question: the institutional apparatus of science and technology policy in Brazil was clearly shown to be unsuitable.

These complex requirements emerged at a time when the country's NIS, which cannot be seen as a finished product but one with several gaps remaining to be filled, was very slow to form suitable institutional arrangements. In addition, the failure to construct collective solutions highlighted the isolation of science and technology issues from other macroeconomic topics; and there was a contradiction between the orientation of scientific, technological and innovation policy and

decisions to tighten macroeconomic policy. These features of the Brazilian economy in the 1990s made it impossible to align the system as a whole with the radical transformations that were arising from the change in technological base worldwide.

In that sense, the 1990s were thus a decade of conflict. On the one hand, economic policy actions were predominantly short-term, heavily constrained by the goals of economic stabilization and control of inflation. This generated (and still generates) recurrent fiscal pressure on the public sector, which is forced to impose highly bureaucratic rules on budgetary management; rules that end up creating obstacles of various kinds and hindering the channeling of resources to science and technology. In this context, the macroeconomic policy orientation reduced degrees of freedom for investment, even in sectors that are crucial to the country's growth and development. Economic policy was also characterized by a tight monetary policy, linked to inflation targeting, which, by keeping interest rates at high levels, caused paralysis in terms of output growth.

The lack of a clear and consistent policy for aligning the Brazilian NIS with the basic features of the new paradigm (mainly knowledge-, information-, and learning-intensive activities) highlights the isolation in which science and technology spent most of the decade. Even experimentation with a new institutional configuration, such as the creation of sector funds, was indisputably undermined by the government's budget constraints, which imposed severe restrictions on practical actions of research and innovative capacity building.

Notwithstanding the urgent need to reform national science and technology and innovation policy in Brazil, it is also essential to overcome the historical contradiction between that policy and the requirements of macroeconomic stabilization.

Until that happens, the defining characteristic of the Brazilian NIS will be its fragility and lack of systemic institutional cooperation, which prevents it from entering on a path of alignment with the new techno-economic paradigm, within the concept of institutional learning proposed.

It is now time to reflect on the institutional bottlenecks in the new Brazilian national innovation system. Even for development agencies, perceiving the radical changes in the nature of the economic environment that occurred in the 1990s, isolated actions are neither profitable nor ideal for achieving any significant outcome that improves the performance of the overall institutional framework. This means that no actor alone can provide support in implanting innovation capacity and competitiveness.

Capacity-building cannot only depend on institutional changes of a merely adaptive catch-up type, especially since the structural changes in the Brazilian economy occurred with little or no knowledge of the characteristics and nature of the new paradigm being established. This means that we did not always adapt in the

direction or in the way in which the features of the ICT techno-economic paradigm were pointing. Those institutional arrangements cannot therefore be seen as the fruits of learning. On the contrary, the structural and institutional changes that took place in Brazil in the 1990s are no guarantee that the system is adapting in line with the paradigm shifts.

A review of this behavior is now urgently needed. Any delay runs the risk of placing the entire Brazilian science and technology system in a state of lock-in, which is even harder to overcome.

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