Paper presented for the VI Globelics Conference, September 22-24 2008, Mexico City

Globelics

Brazil: From S&T to innovation policy?
The evolution and the challenges facing Brazilian policies for science, technology and innovation*

Eduardo B. Viotti[**]

1. Introduction

High and rising levels of labor productivity are at the core of a nation's development. The growth of the labor productivity of any people is a function of its ability to absorb, improve and create technologies.

Although the importance of technological development has been recognized by the majority of policymakers and policy analysts, it has generally been thought of as a byproduct of economic development rather than as a requirement for it.

For decades, Brazilians appear to have believed that technological development –a phenomenon linked to the emergence and multiplication of technologically dynamic enterprises – would arise as a natural consequence, initially of the industrialization process, and, more recently, of the liberalization of the economy.

The science and technology (S&T) policies set in place were in principle expected to lead to the formation of human resources and the production of new scientific and technological knowledge. These policies were almost exclusively dedicated to supporting institutes of research and higher education. Enterprises were rarely the direct target of S&T policies and programs. The role reserved for the productive sector was essentially that of absorbing the knowledge and human resources supplied by the institutes for research and higher education.

Since the end of the 1990s, however, Brazilians have become gradually aware of the need for an S&T policy directly tied to the development process of the country. The promotion of technological innovation has therefore become an explicit and major objective of Brazilian S&T policy. Nonetheless, enterprises – the key agents of the innovation process –

* This is a revised version of a paper written for the International Seminar on Science, Technology and Innovation Policy Evaluation, organized by the *Centro de Gestão e Estudos Estratégicos* (CGEE) and held in Rio de Janeiro on December 3-5, 2007.

** The paper was written while the author was a visiting scholar at the Center for Brazilian Studies, Institute of Latin American Studies, School of International and Public Affairs (SIPA), Columbia University, New York, USA. He is currently a researcher and lecturer on the Master's degree program at the Center for Sustainable Development of the University of Brasília (UnB), and is on leave from his position as a legislative advisor to the Brazilian Senate on scientific and technological policy. E-mail: eduardo.viotti@uol.com.br. (Universidade de Brasília)

are yet to be effectively integrated into the science, technology and innovation (ST&I) policies, most likely due to their traditionally being considered agents external to the S&T system.

This paper has three main objectives. The first is to delineate the evolution of Brazilian ST&I policy and identify its relation to the development policies and the overall development process of the country. The second is to search for evidence confirming the existence of the proclaimed shift from the traditional S&T policy towards one focused on innovation. Lastly, the paper outlines and analyses the main challenges that currently face ST&I policy in Brazil.

Following this introduction, the paper is divided into two sections, with section 2 focusing on the evolution of Brazilian ST&I policy and section 3 on the challenges with which it must contend.

The next section provides a panoramic analysis of the evolution not only of the explicit ST&I policy of the country, but also of the implicit policy present in the model of development followed during each of the principal historical phases of Brazilian development. In the analysis, special attention is given to the contribution of enterprises to the process of technical change and innovation.

The post-World-War II period is divided into three phases. The first, extending from approximately 1950 to 1980, is dealt with in section 2.1, called "In search of development through growth." The second, corresponding to the last two decades of the 20th century, is handled in section 2.2 under the title "In search of development through efficiency." The last phase, which initiated around the turn of the century and is still under way, is tackled in section 2.3 in the form of a question: "In search of development through innovation?"

Supported by the preceding effort to systematize and analyze the evolution of post-war ST&I policy in Brazil, section 3 surveys the main challenges faced by such policy in the current phase of development. It also points to the fact that the recently observed shift towards innovation still has a long way to go to constitute a true innovation policy. Hence, the most important challenge facing current ST&I policy is strengthen the transition to a true innovation policy, and, in turn, to transform it into an effective development policy. Although generating development based on technological advantage is a huge task, the current macroeconomic conditions of the Brazilian economy are creating a historic window of opportunity for this challenge to be successfully met.

2. Evolution of ST&I and development policies

Brazilian development efforts since World War II can be described as falling into three different phases. The first phase, which extended from roughly 1950 to 1980, can be characterized as one marked by the search for development through extensive growth and industrialization.[1]

[1] In Brazil, development based on rapid growth of the industrial sector was actually initiated prior to World

The second phase, which approximately corresponded to the last two decades of the 20th century, was characterized by the search (reluctant at the outset, but progressively more determined) for efficiency, and ultimately development, via the liberalization of market forces. In this period, the dominant perception was that public policies generally hindered more than they helped the development process.

In the present phase, initiated around the turn of the 21st century, the country is searching for a new development model, one that has not yet been clearly defined. Although public policy is again being valued as a tool necessary to development, no rupture has occurred in relation to the importance ascribed to market mechanisms, nor has there been any attempt to reinstate development policies such as those typical of the import substitution period. While it is not yet possible to characterize this phase with precision, it is possible to identify one of its outstanding traits, which is the unprecedented relevance innovation is coming to assume not only with reference to S&T policy, but also with regard to other policies, for example industrial policies, targeted at promoting development. These traits could be pointing to the emergence of a new phase characterized by the search for innovation as the pathway to development, though it should be acknowledged that this possibility has not yet been substantiated.

In this section, the intention is not to present a detailed analysis of the ST&I policy measures implemented in each of the three historical phases, but rather to offer a brief yet panoramic overview of the main characteristics of the science, technology and innovation policies set in place throughout the preceding decades. The presentation will follow an evolutionary approach and be organized according to the restructuring of periods proposed in this paper. This effort to systematize Brazilian ST&I policies focuses on their ties to the technological development of the productive sector as well as to the overall development of the country.

The principal features of each of the three development phases are delineated, together with those of the corresponding ST&I policies. This having been done, the primary impacts on the development process of the policies typical of each of the first two phases are outlined. In turn, the analysis of the current phase concludes with indications as to the trends and features of recent ST&I policy that deserve special attention.

War II. However, only in the early 1950s was a set of measures adopted that could be viewed as the emergence of a true S&T policy. The creation in 1951 of the National Research Council (CNPq) and of the National Campaign for the Improvement of Higher Education (CAPES) is a landmark in the early history of Brazilian S&T policy. Although the attributes and even the names of these institutions were subsequently changed, their acronyms remained the same and their importance to ST&I policy continues to the present day.

2.1. In search of development through growth[2]

The period 1950-1980 was characterized by import substitution industrialization (ISI). The State protected the infant industry, supported foreign and domestic private investment, and created public enterprises in sectors that were considered strategic to national development but failed to attract private capital. The main tenets underlying this approach were derived from development theories, principally from the school of economic thought elaborated by economists and social scientists associated with ECLAC,[3] such as Raúl Prebisch and Celso Furtado. Industrialization was seen as a way to transfer the modern technologies, institutions and social relations characteristic of developed economies to developing ones. Development was profoundly believed to be the outcome of industrialization.

Associated with this model of development was a specific process of technical change, one which would supposedly ensure the technological development of the country. The absorption and generation of technologies were perceived to be natural consequences of import substitution industrialization, and this can be said to have been the S&T policy implicit to the development model in question.[4] This implicit S&T policy was constituted of two elements. The first, understood to be the engine of technological development, was the absorption – via extensive industrialization – of the capabilities required for the production of manufactured goods.[5] The second element reflected the expectation that industrialization itself (i.e., the assimilation of production capabilities) would have as a side-effect the "industrialization" of technical change (i.e., the development of innovation capabilities). During this phase, most economists, policymakers and politicians shared this view.

In the meantime, an explicit S&T policy was being designed and implemented by actors and interests peripheral to the import substitution model of development. This policy focused on fostering research and development (R&D) infrastructure and activities, in other words, on creating and strengthening universities and research institutes, together with forming the human resources required for R&D. In this way, the growing supply of scientific and technological knowledge and of R&D personnel was expected to be used by enterprises for the purpose of generating innovations.

Underlying the interpretation of technical change that guided the explicit S&T policy at the time is the so-called Linear Model[6] of innovation, according to which enterprises are

[2] Information on and evaluations of the Brazilian ST&I policies implemented during the two first phases can be found in Erber (1979), Brasil (1991), Galvão (1993), Gibbons (1995), Schwartzman et al. (1995a, 1995b, 1996a and 1996b), Guimarães (1996) and MCT / ABC (2001).

[3] ECLAC is the acronym for the United Nations Economic Commission for Latin America and the Caribbean, headquartered in Santiago, Chile.

[4] Note that the reference here is to the S&T policy implicit to the development model, and not to the concept more usual in the literature, which concerns the S&T policies implicit in other economic policies, such as those related to the impacts of fiscal and exchange rates policies on the technological development of enterprises.

[5] See Viotti (2002 and 2004) for an understanding of the three basic types of technological capabilities: production, improvement and innovation.

[6] While the idea of the linear(or "science-push") model is far from new, its influence came to prevail as of its systematization in the so-called Bush Report, entitled "Science, the Endless Frontier" (Bush 1945). A rigorous

external agents in relation to the S&T system. Consequently, the role reserved for enterprises is that of users or consumers of the knowledge offered by R&D institutes, even when said knowledge is generated without any view to the effective needs of prospective users.[7]

The Linear Model assumes the existence of a more-or-less direct relationship between R&D efforts and technological innovation, involving a series of stages beginning with basic research. Basic research is therefore the key to the advance of scientific knowledge, opening the way to applied research, experimental development and ultimately innovation per se. For this reason, as research and development – and particularly basic research – progress, they should become the catalyst for a chain reaction leading to technological innovation. The model also assumes that a country that contributes to advancing knowledge will sooner or later reap rewards in the form of technological progress or innovation.

This view of technical change served to inspire the implementation of policies aimed at enhancing the supply of scientific and technological knowledge. This S&T supply policy was essentially delinked from the industrial development policy prevalent from the 1950s through the 1970s.

In this respect, it is important to mention that the II National Development Plan (*II PND*), implemented during the Geisel administration (1974-1979), explicitly included a national S&T policy as an integral part of the national development policy. However, the supply logic of S&T policy was not significantly altered, as Vermulm and Paula (2006, pp. 10-11) point out:

> *Basically, the policy* [the S&T policy of the II PND era] *was strongly directed to research institutes and the formation of highly qualified human resources, leading to the substantial expansion of post-graduate courses. The assumption was that the low level of technological development of the country was due to a deficient scientific and technological infrastructure. Hence arose the priority given to supporting research institutes and the formation of human resources at the post-graduate level.*

A final evaluation of the period indicates that the consequences of the policies adopted during these three decades were mixed. Import substitution industrialization was extremely successful insofar as it led to the establishment of a diversified and integrated industrial park in the country. The policy accelerated the process of economic growth to the point that Brazilian industrialization came to be considered an "economic miracle" in the 1970s, similar to that of China and India in the opening years of the 21st century. However, by the end of the 1970s, the economic growth of the country start to lose dynamism due to waning opportunities for import substitution, a process of technology absorption essentially

analysis of the linear model and of its significance for S&T policies can be found in Stokes (1997).

[7] An important exception to this rule was the technological effort led by State enterprises such as Petrobras and Embraer, which owe much of their success to R&D activities and human resource formation developed with specific purposes either internally or in conjunction with learning and research institutions .

dependent on the expansion of import substitution and the unfavorable international environment of the day.

The growth leveraged by industrialization led the first element of the S&T policy implicit in the development model (i.e., the absorption of the capabilities required for the production of manufactured goods) to a successful outcome. However, the second element (i.e., the "industrialization" of technical change) was essentially a failure. This element was shown to be based merely on unrealistic expectations as to the capacity of industrial enterprises to develop capabilities for generating technology improvements and innovations out of their recently acquired production capabilities. Likewise, the S&T policy explicitly aimed at increasing the supply of knowledge (albeit delinked from the needs of industry) also appears to have contributed little towards enhancing the enterprises' capabilities for technological improvement and innovation. In fact, since the productive sector rarely took advantage of the supply of knowledge made available through implementation of the policy, the supply could be said not to have found its demand. The technological dynamism of the country therefore continued to depend primarily on the absorption of technologies generated and/or improved abroad. At the same time, the usual reasons for such absorption – the emergence of new economic sectors or the growth of the domestic market – were losing strength.

In time, developing technological capabilities for the improvement and innovation of products and processes would become essential for raising the low productivity and competitiveness levels of the Brazilian economy. However, raising these levels would depend on sustaining the economy growth once the import substitution process had been exhausted, be it through broadening the domestic market, raising income via productivity gains or conquering new foreign markets.

Although economic growth was exceptionally strong during all three decades, economic development proved to be elusive. Once the sources of this growth had been depleted, they had not yet been adequately complemented or replaced by endogenous technological development, while the capacity to absorb exogenous technologies was still limited. Furthermore, the levels of poverty and inequality remained extremely high and far from compatible with the standards typical of developed economies. The first phase therefore ended in the midst of macroeconomic and fiscal crises, which, among other problems, severely compromised the capacity of the State to implement development and S&T policies adapted to the new structural conditions of the Brazilian economy.

2.2. In search of development through efficiency

In Brazil, the second postwar development phase, a period that roughly corresponded to the last two decades of the 20th century, was marked by progressive liberalization of the economy. Initially with reluctance, but eventually with determination (especially as of 1990 during the Collor administration), the institutional and regulatory apparatus created over the previous decades in support of industrialization was gradually dismantled. Simultaneously, the general opinion of economists, politicians and opinion makers turned against policy prescriptions based on the development theories of the previous period. In fact, the very

industrialization policies founded on these theories came to be blamed for the high levels of inefficiency and the persistent economic and technological backwardness of the country, in other words, for its lack of development.

The search for efficiency came to be one of the priorities of economic policy. Despite the concept of efficiency having been defined (according to the traditional economic theory that gives support to liberalization) within an essentially static context, where there is no room for technological change, the search for efficiency was presented as one of the principal engines of technological progress. The order of the political day came to be terms such as privatization, deregulation, the reduction or removal of subsidies and tariff or non-tariff barriers to foreign trade, free exchange rates and free capital flows – as the measures inspired by the Washington Consensus, the set of economic reforms recommended for developing countries as of the early 1980s came to be called, all with the support of the International Monetary Fund, the World Bank, the Inter-American Development Bank, the North-American government and the leading economic research institutes ("think tanks") located in the city.[8]

The opening of the economy to international trade came to be considered the key to growth and development, thus ascribing to liberalization the role formerly played by industrialization in underdeveloped economies. According to this conviction, the more open the economy, the greater it's potential for growth.

The opening of the domestic market to products, services and capital from abroad was also tacitly understood to be the principal instrument for the implicit S&T policy linked to the new development model.[9] The increased competitive pressure arising from liberalization was expected to eliminate the protection that allowed enterprises that employed stagnant or antiquated technologies to profit, thus forcing them to innovate. At the same time, the opening of the market was also expected to facilitate and accelerate technological transfers from abroad via foreign direct investment (FDI).

To an extent, the explicit S&T policy of the era upheld the tradition of promoting R&D activities. However, the prolonged fiscal crisis and the short-term approach to the administration of public policies led to significant fluctuations with respect to the support offered R&D activities and institutions in the 1980s and 1990s. During the 1990s, for instance, federal investments in R&D rose until the middle of the decade, then fell to levels only slightly above those at the beginning of the period (MCT 2001, p.23). As a result,

[8] It is worth noting, as did Williamson (1990, p. 20), who consecrated the name of the doctrine, that, surprisingly, this prescription for underdeveloped economies was elaborated without taking into account a single idea from the literature on development theory or any work dedicated to discussing or questioning it.

[9] For example, Gustavo Franco, director of the Brazilian Central Bank at the time and important ideologue of the Brazilian liberalization process, clearly expressed the opinion that it is "precisely the process of opening, by means of its effects on the technological dynamism of the country, what will define the basis of the new cycle of growth." He also states the importance of the opening of the economy as "essential to the accelerated growth of productivity, and therefore the mechanism that would allow for... the construction of a growth model capable of reducing social inequality without inflationary impacts." (Franco 1996, p. 2)

many learning and research institutes faced budget problems, wage cutbacks and reductions in the number of professors, researchers and technical staff.[10]

Despite these difficulties, the other traditional area guided by S&T policy – the formation of human resources for research and development – surprisingly advanced in systematic and accelerated fashion. Hence, the Brazilian post-graduate system rapidly expanded and consolidated during this period.

In addition to the two traditional aspects of S&T policy, five new aspects either emerged or gained significance during these years.

The first of these refers to the greater importance ascribed, at least with respect to concern or the political discourse, to the issue of the quality and expansion of the educational system, and especially of basic education. Attention was called to the fact that a well-educated workforce was prerequisite to raising the technological capabilities of Brazilian enterprises. All too often, however, the theme was approached in an overly simplistic manner, as if education alone were sufficient for development, or a universal panacea capable of replacing all other policies (including those directed to S&T).

The second new aspect has to do with the reform of the intellectual property regime (IP) in order to satisfy the regulations of the TRIPS Agreement of the World Trade Organization (WTO) and attend to the strong pressures from the North-American government.[11] Long before the creation of the WTO (1995) and the approval of the new patent law (1996), the reform had already begun with measures that hindered the National Industrial Property Institute (INPI) in its attempts to apply the earlier regime, and especially the provisions aimed at granting Brazilian enterprises stronger bargaining power or facilitating technological transfers.[12] The intention of the reform was to transform scientific and technological knowledge from an essentially public good (which allows it to be simultaneously employed by various users) into an essentially economic good (which the concession of farther reaching and longer lasting monopolistic rights of exploitation to proprietors). There was thus an evident shift to the advantage of the innovators, which were usually foreign enterprises, and to the disadvantage of those that absorbed the new technologies, which were generally domestic enterprises. The goal of the new regime was to stimulate innovation among the enterprises established in the country, regardless of their origin of capital. It was also meant to increase the number and enhance the quality of the technologies and trademarks for which licenses to operate in the Brazilian market were granted, these objectives to be met thanks to a new regulatory environment that offered more guarantees, further rights and, consequently, higher profits to those who held the licenses.

[10] In great part, these reductions were due to many retiring when faced by the prospect of prejudicial social security reforms, as well as their not being replaced by new personnel.

[11] The IP reform was consolidated via enactment of laws pertaining to industrial property (Law n° 9.279 of 1996), agricultural variety rights (Law n° 9.456 of 1997), copyrights (Law n° 9.610 of 1998) and software rights (Law nº 9.609 of 1998).

[12] This occurred owing to the regulatory acts of INPI itself, namely the revocation of Regulatory Act n° 15 of 1995, promulgated via Regulatory Act nº 22 in 1990, and the promulgation of Regulatory Act n° 120 in 1993.

The third new aspect of S&T policy was the initiation and consolidation of the accelerated dissemination of quality control practices, stimulated by the creation of the Brazilian Quality and Productivity Program (PBQP) in 1990.[13] Termed a mobilization program at the time, it was designed to encourage enterprises to adopt best practices, even in the absence of funds specifically earmarked for the purpose. In fact, however, it is more likely that the spread of such practices reflected less the efforts of the PBQP than the pressures to which Brazilian enterprises were being submitted. Faced by a macroeconomic environment in which demand was stagnant, credit extremely scarce and competitive pressure on the rise, many enterprises had recourse to defensive strategies, among which quality management was often considered the best option; for it was seen as a way to bolster competitiveness and cut costs without the need for new investments.

The dynamism of the spread of best management practices can be inferred from the enormous growth in the number of public and private entities that have come to operate with the ISO 9000 certification granted by the International Organization for Standardization. Whereas only 19 Brazilian institutions were ISO certified in January 1993, the figure had risen to 6,719 by 31 December 2000. Moreover, the number of certified institutions has risen 25 times faster in Brazil than in the world as a whole (ISO 2001). It is important to note, however, that advances in the quality of Brazilian production cannot be expected to leverage and thus accelerate innovation. What these advances have most likely achieved is to have strengthened the production capabilities of enterprises, thereby better enabling them to improve products and process and engage in incremental innovation.

The fourth new aspect of explicit S&T policy concerned the stimulation of entrepreneurship and the establishment of incubators and technological parks. Although many of these incubators and complexes merely encouraged the creation of small firms in traditional sectors and contributed only marginally to raising the existing technological standards, a fair number of these institutions were dedicated to promoting truly innovative undertakings. Most of the public programs and measures aimed at fostering incubators and technological complexes initially arose in the late 1980s and gained strength over the following decade. According to the estimates of the National Association for the Promotion of Innovative Activities, the number of incubators in Brazil climbed from only two in 1988 to 150 in 2000 and 359 in 2006 (Anprotec 2006). In the same year, Anprotec identified the existence of 44 technological parks in the country.

The fifth unprecedented aspect was to treat innovation as a policy objective. It was possible for innovation to overcome the barriers imposed by the liberals in the debate surrounding public policy because it could not be associated with the by then execrated former development policies, and could actually be seen to approach the ideas of free initiative and entrepreneurship, both of which are concepts dear to liberalism. In this regard, the liberals accepted bringing innovation into the discussion because they understood it to be a more or less natural outcome of the suitable rewards and punishments accompanying the liberalization of the market. However, as time passed and frustration grew in relation to the high expectations associated with liberalization, innovation gained strength as a goal to be

[13] In 2001, the responsibilities of the PBQP were transferred to the Brazilian Competitiveness Movement, a NGO of public interest http://www.mbc.org.br).

actively pursued by public policy. As a result, innovation became increasingly significant not only in the S&T sphere per se, but in regional, state and municipal development policy as well. By the end of the 1990s, innovation was already held to be an integral part of science and technology policies, or at least one of its explicit objectives.

Nonetheless, bringing innovation into the political discussion proved far easier than putting it into political practice, for the Linear Model still had strong influence, especially in academic circles. In part, this had to do with the enormous influence that the academic community wielded (and continues to wield) in the formulation of Brazilian S&T policy. It is important to note that the extent of this influence is partly owing to the limited participation of other social sectors, and specifically members of the productive sector, in S&T policymaking. Another reason for the persistence of the Linear Model is related to its long tradition and the familiarity of individuals and institutions (including regulatory entities) with the programs and mechanisms typical of the linear supply model. At the same time, actual policymaking have shown important difficulties in the process of designing and implementing programs and mechanisms better suited to a genuine innovation policy.[14]

In this respect, Pacheco (2007, p. 9) contends that:

> *Examination of the policies reveals that the success of post-graduate courses, compared to the dismal performance of the private sector, reinforced the 'supply' side of the policy and the asymmetry of the system. The consolidation of post-graduate courses reflected a tremendous effort to qualify personnel and fortify academic research; and while it should have been accompanied by the technological strengthening of enterprises, this had always been the weak side of the model. Thus, instead of leading to revision of the policy, it reinforced the 'academic' side and came to lean in two directions: the success of the post-graduate system created strong pressure on the allocation of public funds, while the policies and measures aimed at supporting R&D at the firm level came to be thought of in the same terms as those directed to supporting academic research, rather than being seen as belonging to the sphere of economic policy.*

Final assessment of the period indicates that the policies adopted in the 1980s and 1990s were considerably less successful than anticipated. Although highly qualified human resources – with Master's degrees and PhDs – were formed and scientific production

[14] That the traditional economists (those belonging to the neoclassical school) prevailed in the debate concerning public policy also contributed to extending the life of the Linear Model. For these economists, the only justification for the existence of public policies was the need to correct market failures, a typical case being that involving the production of scientific and technological knowledge, principally in the stage of basic research. Since a great part of the results of the investments in such activities would ultimately be appropriated by parties other than those who paid for them, State intervention would be required in order to raise the volume of R&D investments to levels compatible with the maximization of efficiency and social well-being. By definition, this market failure is specifically linked to research that has no immediate use or application as its objective, i.e., to basic research. Obviously, the same logic does not apply to policies directly targeted at stimulating innovation. For this reason, the latter are held to destabilize the maximum efficiency and well-being equilibria, which are assumed to be naturally maintained by market forces.

expanded at elevated rates, technological development and innovation did not keep pace, apparently having registered less-than-significant evolution.

In 1987, for example, 3,647 Master's degrees and 868 PhDs were granted by Brazilian institutions, but by the end of the phase, in the year 2000, the corresponding figures had risen to 18,373 Master's degrees and 5,335 doctorates (CAPES 2004, p. 29-30). This increase in post-graduate degrees was accompanied by a similar increase in the number of articles published by Brazilians in international scientific journals. Whereas in 1981 Brazilians had authored only 1,891 articles, corresponding to 0.44% of the total indexed worldwide by the Institute for Scientific Information (ISI), by 2000 they were producing 400% more, with 9,591 articles and 1.33% of the total.[15]

Though a longer period of time may be required to adequately appraise them, the changes in the industrial property regime do not appear to have the expected results within the initial timeframe. Between 1990 and 2000, the number of patents granted to Brazilian residents rose a mere 30%, while the number granted to non-residents increased by 154%. Consequently, the relative share of patents granted to Brazilians (already low at 30%) fell to 18% over a 10-year period (INPI/MCT 2007). During the 1990s, over 100 thousand patents for inventions were registered by non-residents. The right to use this increased and huge number of patented inventions obviously depended on the concession of licenses by their owners, interestingly though the number of license applications submitted to INPI dropped from an already extremely low 134 in 1990 to no more than 34 in 2000 (INPI 2008).[16] If this number can be taken as an indicator of the magnitude of technological transfers to the country, the new intellectual property regime can be said to have had results contrary to expectations.

The average productivity of Brazilian labor (measured as GDP at constant purchasing power parity prices divided by the number of workers employed) stagnated throughout the 1980s and 1990s (Viotti 2004). In spite of the overall average having remained basically constant, certain sectors of the economy recorded positive productivity gains. There are indications, however, that the greater part of the rise in productivity in these sectors was due more to the acquisition of capital goods and changes in sectoral composition than to innovation and technological change per se. As Kupfer and Rocha (2005, p. 75) emphasize, "the modernization [of industry] was based not on sustainable long-term strategies – such as the installation of new production units – but on the renewal of equipment – via the importation of capital goods – and the restructuring of ownership through mergers and acquisitions." The productivity gains observed in the industrial sector therefore reflected a concentration of output among the leading enterprises (which had relatively high productivity and were increasingly under the control of foreign capital), a rise in the coefficient for imported inputs and components, and a drop in the significance of industrial

[15] In 2007, Brazilians published 19,428 scientific articles, corresponding to 2.02% of total world production. Whereas worldwide scientific production doubled over the period 1981-2006, Brazilian output increased ninefold (CAPES 2008).

[16] Article 62 of the Industrial Property Law (Law nº 9.279 of 1996) requires that third parties be licensed by INPI. However, it does not require that the right to exploit patents be licensed by the Institute, unless the party concerned wishes to claim tax deductions referring to the payment of patent licenses, in which case registration is necessary.

employment. In compensation, informal employment increased substantially in the economy as a whole.

The structure of Brazilian foreign trade changed significantly during the opening of the economy. However, aside from the exceptional performance of Embraer (an aircraft manufacturer founded and developed by the State but under private control at the time), the technological content of Brazilian exports was generally impoverished. In fact, the trend was towards regressive specialization of the export content, insofar as the shares of natural-resource and labor-intensive goods once again increased. Regarding this point, Viotti and Macedo (2003, p. xxxiv) confirmed (on the basis of Sarti and Sabbatini 2003, p. 400) that "the product group that contributed most to the overall growth of Brazilian exports [in the period 1989-2001] was comprised of primary commodities, among which meat, sugar and soybean oil stood out, accounting for 24% of the total increase in Brazilian exports."[17] The fact that these three products were responsible for only 0.5% of the growth of world exports over the same period serves to underline the limitations of a growth strategy based on primary commodities.

In sum, the economy was liberalized, but its growth was mediocre up to the end of the period. Not even the strong increase in competitive pressure, the opening of the economy to foreign investment and the strengthening of intellectual property rights had the capacity to effectively stimulate the development of a true innovation dynamic among Brazilian enterprises. In other words, the implicit S&T policy linked to the search for development through efficiency is apparently grounded on an overly simplistic as well as overly optimistic interpretation of the process of technical change, being similar in this respect to the policy underlying the industrialization model.

Moreover, with the economy slowing down and poverty and inequality remaining at unacceptably high levels, disillusion with the promises of the Washington Consensus was on the rise. This disillusion was among the factors that contributed to the election, at the end of 2002, of an administration that offered a platform considerably different from the agenda set forth by the Washington Consensus. The new platform proposed another type of development, one less concerned with competition and efficiency and more strongly committed to social inclusion.

2.3. In search of development through innovation?[18]

The third postwar development phase began around the outset of the 21st century and has been marked by the search for a new type of development. In great part, the foundations that had inspired the policies typical of the agenda in the preceding phase were maintained,

[17] It should be emphasized that the success of these agricultural exports was in great part due to the R&D efforts of Embrapa. A network of agricultural institutes founded by the federal government in the latter part of the 1970s, Embrapa has consolidated its position over the last three decades and merits analysis apart.

[18] For a discussion of recent Brazilian ST&I policy, see Arruda, Vermulm and Hollanda (2006), particularly the chapter on the new instruments of technological policy on p. 82-114. Also see MCT (2002), Brasil (2003), Guimarães (2006), ABDI (2006 and 2007), Salerno and Daher (2006), Vermulm and Paula (2006), MCT (2006), Suzigan and Furtado (2006), Pacheco (2005 and 2007) and MCT (2007).

with the trio "floating exchange rate, inflation target and primary surplus" continuing to lie at the core of economic policy. However, experiments came to be conducted in an attempt to strengthen certain public policies not precisely aligned with the former agenda.

The diminishing belief in the liberal platform has allowed for gradual revalorization of the role of active public policies as a tool necessary for the promotion of development.[19] It must be recognized, nonetheless, that the extent to which such policies can be formulated and implemented has been considerably reduced by the current mobility of capital, goods and services (characteristic of globalization), as well as by the regulations of the WTO, which went into effect together with its creation in 1995. Given the new environment, many former policy practices have become either obsolete or unfeasible.

At the same time, the significant strengthening of social and compensatory policies as of the beginning of the new phase clearly reflects a revalorization of the role of public policy. An outstanding example is the *Bolsa Família* program, which in 2008 guaranteed a minimum income to more than 40 million Brazilians below the poverty line.

The search for a new development model still lacks a clearly defined policy paradigm. Instead, it continues to be influenced by essentially mixed and sometimes divergent approaches. Some characterize it as a a combination of a conservative approach to economic policy together with a progressive approach to social policy.[20]

In a context marked by the lack of a unifying logic, it is not yet possible to discern the emergence of an implicit S&T policy with well-defined features within the new development model. However, continuing to follow a conservative monetary policy (exclusively committed to achieving inflation targets with no concern for variations in investment, employment and income levels) has unquestionably had a strong indirect impact on the technological development dynamic of enterprises.

Measured in real terms, the basic interest rate of the Brazilian economy remained at extremely high levels throughout the first years of the 21st century, being the highest in the world during a great part of the period. Simultaneously, the exchange rate, influenced by various factors, including monetary policy itself, was initially devalued (up to 2003), but rapidly revalued thereafter. This combination of high interest rates and overvaluation of the national currency has hindered productive investment in general, and especially investment in activities with long-range returns, such as R&D and innovation. Enterprises and links in

[19] In this respect, one should remember, as do Lall and Teubal (1998) in their interesting and instructive analysis/proposal for technological policies in developing countries, that active policies are not necessarily State attempts to substitute the market. In other words, despite what certain critics claim, they are not anti-market policies. As a rule, they are actually market-stimulating policies, as shown by the experience of the East Asian countries analyzed by Lall and Teubal.

[20] This interpretation was used, for instance, by Michael Reid, editor of the Americas section of *The Economist*, in his article "Ya es mañana en Brasil," published in the Madrid newspaper *El País* on June 19, 2008 (http:// www.elpais.com/articulo/opinion/manana/Brasil/elpepiopi/20080619elpepiopi_12/Tes). In support of his assessment, Reid cites the President himself: "During a press conference promoted by *The Economist* in Brasília… Luiz Inácio Lula da Silva addressed a well-phrased, good-humored speech, in which he transmitted a simple message, to an audience of businessmen. He said that his political formula relied on being 'conservative in economic matters' and 'audacious in social matters'."

productive chains dedicated to activities with high value added have been particularly affected. In contrast, enterprises that operate in sectors intensive in natural resources (specifically commodities sectors) and whose competitive strategies have little dependence on investment in R&D and innovation have been relatively favored.

However, in contradiction to the S&T policy implicit in the previous development model, awareness has been growing as to naivety of the belief that opening the economy, strengthening intellectual property and encouraging foreign investment would automatically lead to extensive firm-level innovation.[21] As a result of this awareness, the adoption of active policies to stimulate innovation has assumed growing importance in the economic, industrial and S&T policy debate. In this regard, explicit S&T policy, similar to social policy, has become a fertile field for policy experiments. An important and complex set of S&T policy measures was instituted at the start of the most recent development phase. Among these, the following stand out: the Sectoral Funds, the Law of Innovation, the Industrial, Technological and Foreign Trade Policy (PITCE), and a law granting fiscal incentives to firms that engage in R&D and technological innovation (*Lei do Bem*).

The Sectoral Funds in Support of Scientific and Technological Development were established during the final years of the Cardoso administration. The intention was to assure the availability and growth of resources for scientific and technological development and innovation in Brazil. The funds are financed by shares of the royalties on the oil and gas produced in the country and contributions levied on the revenues of enterprises in given sectors or on certain types of transactions, such as those referring to payment for the use or acquisition of foreign technology. There are currently 16 sectoral funds, 14 referring to individual sectors and two involving more than one sector (MCT 2008).[22]

In the opinion of Arruda, Vermulm and Hollanda (2006, p. 102):

> *The resources provided by the revenues earmarked for the sectoral funds were indeed significant and halted the declining trend observed in the MCT* [Ministry of Science and Technology] *budget throughout most of the 1990s. Between 1999 and 2005, the budget handled by the Ministry rose from* [R$] *1.397 billion to* [R$] *3.589 billion, corresponding to a real growth of approximately 27% over the period and an average annual growth rate of 4.5%. The sectoral funds accounted for almost 80% of this growth.*

Inspired by the North-American Bayh-Dole Act and the French innovation law, both aimed at stimulating the contribution of public university and research institutes to the innovation process, the Brazilian Law of Innovation[23] was enacted during the first term of President Luiz Inácio Lula da Silva. The law regulates the transfer to private enterprises of the

[21] It should be noted in passing that, as previously mentioned, the first phase of postwar Brazilian development was also marked by a certain naivety. During the import substitution period, it was believed that technological development would be the natural outcome of the mere absorption of the capacity to produce manufactured goods, i.e., would be a byproduct of industrialization.

[22] Of the latter, one of the funds is aimed at stimulating university-industry collaboration, while the other is directed towards modernizing and expanding the infrastructure and services required by public learning and research institutions.

[23] Law n° 10.973 of 02/12/2004.

technologies generated by public institutions, as well as allowing the latter to share their infrastructure, equipment and human resources with the former.[24] It also authorizes the federal government to hold minority shares in the capital of private enterprises constituted as specific purposes companies on the condition that the latter are dedicated to innovation. Likewise, the law allows the government to subsidize enterprises by granting them financial resources for the purpose of developing innovative products and/or processes. Finally, it authorizes public administrators to solicit the development of technological solutions when innovative products or processes are required to attend to the public interest.

Other legislation, curiously termed the Good Law (*Lei do Bem*),[25] consolidated and amplified existing fiscal incentives, as well as extending substantial new incentives, to enterprises that engage in R&D and technological innovation. In addition, the law authorizes the federal government to grant subsidies to firms that contract researchers with Master's or doctoral degrees for the purpose of undertaking R&D and technological innovation activities.

The bases of the new Industrial, Technological and Foreign Trade Policy were laid through publication of the guidelines at the end of 2003 (Brasil 2003). According to these guidelines, the goals of PITCE were to "increase the efficiency of the productive structure, enhance the innovative capacity of Brazilian enterprises and expand exports" (Brasil 2003, p. 2). Arruda, Vermulm and Hollanda (2006, p. 83-84) have called attention to the fact that the document seeks "to differentiate PITCE from the industrial policies of the 60s and 70s, which focused on expanding the physical capacity of the industrial complex, as well as from the policies of the 90s, which sought to promote competitiveness but were not directly tied to any industrial development policy."

Both complex and ambitious, PITCE set priorities on three fronts: *1)* innovation and technological development, modernization of the industrial sector and improvement of the institutional environment; *2)* enhancement of production capacity/scale and strategic options (semiconductors, software, capital goods, pharmaceutical and medical products); and *3)* future bearer sectors (biotechnology, nanotechnology, biomass and renewable energy). Moreover, numerous institutional and regulatory measures, programs, activities and credit lines were created, reoriented and implemented by several governmental institutions within the loose umbrella of PITCE.[26] As hard as it has often been to achieve the objectives of PITCE in the face of numerous obstacles and limitations, and despite its priorities having been considerably redefined recently,[27] the policy has recorded at least

[24] In this respect, the Law of Innovation reflects high expectations in relation to the role of public universities and research institutes in the innovation process. At times, certain enthusiasts of the law seem to exaggerate the potential contribution of these institutions by portraying them as as capable of offsetting the limited number of truly innovative firms in the country.

[25] Law n° 11.196 of 21/11/2005.

[26] Salerno and Daher (2006) present a long list of the measures implemented by PITCE since the publication of its guidelines in November 2003 until June 2006.

[27] When this paper was written, a new industrial policy was on the verge of being announced. Unfortunately, given the timing, it was impossible to analyze the new policy in the context of this study. The same applies to a key document published at the end of 2007: the MCT *Plan of Action for 2007-2010: Science, Technology and Innovation for National Development.*

two significant victories. Firstly, PITCE resuscitated industrial policy, which had been abandoned during the preceding development phase. Secondly, it represented the first explicit attempt – in Brazil – to align industrial and technological policy.

In addition to these four initiatives, the most significant of the explicit S&T policy of the period (the Sectoral Funds, Law of Innovation, "Good Law" and PITCE), four recent trends that deserve mention are: *1)* the growth of media interest in ST&I issues; *2)* the increase in the number of states and municipalities striving to formulate their own ST&I policies; *3)* the effort to design an ST&I policy aimed at promoting social inclusion; and *4)* the adoption of Local Productive Arrangements (LPAs) as a tool for guiding analyses and interventions aimed at stimulating localized innovation, technological and productive development.

While not easy to measure, it is easy to perceive the growing interest of the Brazilian media in themes related to science, technology and innovation. At the same time, the level of this interest is still relatively limited compared to that in countries engaged in accelerated catching-up processes, such as South Korea.

The Federal District, the states and an increasing number of municipalities are also becoming increasingly interested in the theme. Various states have set up secretariats and many have programs and policies exclusively dedicated to ST&I. The phenomenon gained impetus with the Constitution of 1988, which authorized states to support such activities by earmarking state tax funds for the purpose, a pioneer experience along these lines being the Research Support Foundation of the State of São Paulo (FAPESP). However, the most recent evidence of the trend is the appearance of interest on the part of cities. Similar to the states, various municipalities have come to view innovation as a way to promote regional and local development. This involvement of states and municipalities in ST&I policy is now being formalized in the shape of national institutions for the sake of sharing experiences and defending common interests. Among these institutions are the National Council of State ST&I Secretariats (http://www.consecti.org.br) and the National Forum of Municipal Science and Technology Secretariats (http://www.forum-municipal.org.br).

A new specific segment of the ST&I policy aims at placing S&T at the service of social inclusion. To this end, the Ministry of Science and Technology (MCT) created the Science and Technology Secretariat for Social Inclusion (SECIS) in 2003.[28] So far, SECIS has promoted activities to publicize and disseminate social technologies,[29] improve science teaching in the schools and popularize scientific knowledge.[30] Nonetheless, since the

[28] Interestingly, the MCT has only four secretariats, of which this is one. The other three are dedicated, respectively, to informatics (reflecting the importance of the IT policy theme in the recent past), to R&D, and to technology and innovation.

[29] Actually, the concept of social technology is still under construction. Dagnino, Brandão and Novaes (2005) present an analysis of the conceptual framework on which the notion rests. The Brazilian Social Technology Network (RTS) adopts the following definition: "Social Technology involves replicable products, techniques and methods developed through interaction with the community and characterized by their ability to provide effective solutions for social transformation" (http://www.rts.org.br/tecnologia-social).

[30] Among the most successful activities along these lines have been the annual math Olympics and other initiatives aimed at strengthening the learning of mathematics at the secondary level. The 2008 Olympics are

solutions to the social problems of Brazil probably depend far more on factors other than the generation and dissemination of scientific knowledge, this line of policy has come under criticism from those who do not see social inclusion as being within the sphere of ST&I policy. Although the scope and efficacy of such instruments can also be questioned, this line of policy had the merit of effectively introducing the issue of ST&I contribution for aggravating or alleviating the social conditions of the greater part of the Brazilian populace into the Brazilian policy agenda.

While not always observing a precise understanding of the concept of Local Productive Arrangements (APLs, in its Portuguese acronym), the approach linked to this relatively new concept has proven to be an extremely useful tool for analyzing and guiding interventions focused on technological change and innovation. One of the most important aspects of this approach is its emphasis on cooperation and networking among suppliers, producers, service providers, enterprise and labor associations, local governments, universities and other public and private institutions. A great number of federal, state and municipal programs and agencies, as well as trade and industry associations, are currently working with APLs.[31] Assuming that the abuses practiced in their name do not undermine the potential of the APLs, they may well consolidate as an effective means of strengthening practices capable of leading to a policy paradigm no longer based on the Linear Model, but rather on a systemic approach. Such a paradigm would allow for the collective inclusion of micro, small and medium enterprises in technological and innovative efforts, a step unquestionably representing an advance given the historical difficulty of dealing with this segment via programs that sought to reach it on a firm-by-firm basis. It would also serve to overcome the general notion that issues connected to ST&I are only of interest to a small elite composed of scientists, researchers, university professors and, ultimately, of large enterprises endowed with state-of-the-art technologies.[32]

In sum, the traditional approaches to S&T policy – support to R&D and the formation of professionals with Master's and doctoral degrees (both of which reflect the linear supply model) – have continued to advance in a pattern similar to that of the former development phase. They have come to be accompanied, however, by an expressive set of new measures and trends, each of which in one way or another diverges from the policies typical of the paradigm inspired by the Linear Model.

The Sectoral Funds, the Law of Innovation and the "Good Law", as well as the formulation of a policy that is simultaneously industrial and technological (PITCE) – all indicate that Brazilian S&T policy is shifting towards the enterprise and the productive sector. Similarly, the discovery of ST&I policy as a potential tool for the regional and local development of states and municipalities, together with the recognition of the utility of the APL approach as an instrument for organizing local systems for production and innovation, confirm the notion that innovation is assuming a more important role in policies directed to the

expected to involve more than 18 million students and over 4 thousand schools representing nearly all the municipalities in the country (http://www.obm.or.br and http://222.obmep.org.br).

[31] A Google search using the term "Arranjos Produtivos Locais" (in Portuguese and between quotation marks) identified approximately 120 thousand pages on the subject on the Internet.

[32] Regarding APLs, see, for example, "Seminário Dez Anos de Arranjos e Sistemas Produtivos e Inovativos Locais" at http://www.redesist.ie.ufrj.br/redesist10/.

scientific and technological development of the country, in accordance with the concept of a National Innovation System, or so-called Systemic Model.

Hence, there are indications that S&T policy, in this third postwar phase of Brazilian development, is moving in the direction of technological innovation. Assuming this to be the case, two questions arise: *1)* Is Brazil effective shifting from an essentially linear, supply-side S&T policy to a true systemic, innovation-based policy? *2)* Will the country have the opportunity to enter another development phase in which the growth of income and the quality of life of the population comes to depend, above all, on innovation and technological capabilities, as in the developed economies?[33]

3. Challenges to the building of an effective innovation policy

An effective innovation policy is prerequisite to building the foundations of Brazilian development.

In the closing years of the 20th century and the opening years of the 21st, there were significant advances towards creating an environment favorable to mounting an innovation policy in Brazil. These advances involved not only ideas, but instruments and structural conditions. In the sphere of ideas, doctrines and scientific theory, neoliberal thought — which had condemned developing countries to resigning themselves to destinies determined by the market and to abdicating the right to invest in their project of future by implementing active policies — lost steam. The comprehension of the fact that technical change lies at the core of any true development process became more widespread because of the gradual introduction of this variable within conventional economics, which was originally took as a variable exogenous to its theoretical core. Meanwhile, evolutionary or neo-Schumpeterian theories advanced significantly the understanding of the phenomenon of technological innovation and contributed to formulating the reference framework for the conception of modern ST&I policies with the development of the National Innovation Systems approach.

With regard to instruments, as seen in the preceding section, a set of diversified and important policy measures were explicitly adopted with the goal of stimulating innovation in the country. In the evaluation of some analysts, the mounting of the innovation policy apparatus has essentially been concluded. This appears, for example, to be the opinion of Arruda, Vermulm and Hollanda (2006, p. 106), when they affirm that:

> *There is no doubt that, in recent years and inspired by international experience, the country has advanced considerably toward creating an institutional apparatus better suited to stimulating innovation. When the instruments existing in Brazil are compared to those in more developed countries, nothing appears to be lacking, despite there still being gaps and a need to improve certain aspects of the legal framework. We now have access to a broad range of new instruments designed*

[33] See Viotti (2004) for an explanation of why development depends on authentic competitiveness (based on technological gains), while underdevelopment reflects spurious competitiveness (based on protectionism, cheap labor and predatory exploitation of natural resources).

> *according to international best practices, as well as to a significant volume of resources for supporting the R&D and innovation projects of enterprises in various ways and in diverse stages.*

Even so, these same authors recognize that it is extremely hard to put the new instruments into operation (Arruda, Vermulm and Hollanda 2006, p. 107-12).

It is admittedly not an easy task to substitute the conviction, prevalent for decades, that research, and especially basic research, is the key, the very catalyst, of technological development. Consequently, as recent ST&I policy has demonstrated, it is easier to formulate goals, justifications and programs inspired by the systemic approach than to execute them while leaving aside the traditional practices inspired by the Linear Model; for, in the end, the latter influence or dominate the implementation of the former.

Unfortunately, since the Linear Model has been neither replaced nor entirely displaced, it continues to exert strong influence, particularly among scientists and scholars.[34] Given the force of inertia, R&D objectives supposedly inspired by the Systemic Model are ultimately implemented through means associated with the Linear Model.[35] For example, a relatively small proportion of the resources applied by the Sectoral Funds is directed to supporting the innovation efforts of enterprises.[36] All too often, the selection processes for support

[34] It should be stressed that the WTO regulations also contribute to this. The Organization's general prohibition of subsidies and other forms of protection significantly diminishes the extent to which policies can actively support enterprises. At the same time, its excepting subsidies for R&D, but not for other types of innovation activities, clearly reinforces the adoption of policy measures aligned with the Linear Model.

[35] In practice, the difficulties involved in consolidating policies based on the systemic approach are not a Brazilian problem alone. Despite the differences, a similar problem exists in Europe. Arundel and Hollanders (2006, p. 2) point out that though reference is no longer made to the science-push or linear model based on R&D, close analysis of the main policy documents indicates that "the concept of innovation in use is primarily R&D." Moreover, "the main innovation policy instruments in all European countries either subsidize R&D or are linked to R&D" (Arundel and Hollanders 2006, p. 3). In confirmation of this assessment, Arundel (2006, p. 4) estimates that, in Europe, "programs that do not involve R&D probably account for less than 5% of all government support for innovation." An OECD (2005, p. 7) report comes to a similar conclusion: "The innovation policy of the OECD countries has been seen as an extension of R&D policy. As such it has been linked to research and technological development. This remains to be the case, even though the systemic approach developed under the label of 'National Innovation Systems' (NIS) during the 1990's expanded this perspective to include interactive linkages in the innovation system."

[36] Though somewhat dated, this is the conclusion of the known evaluations of the Sectoral Funds (IEDI 2005 and Pereira 2005). IEDI (2005), for example, states that the "funds were mainly allocated to renewal of the public research infrastructure and academic research, with no clear connection to sectoral or national priorities, or to the formation of human resources, thus complementing CAPES and CNPq. A considerable portion of the funds was also directed to activities such as planning, studies and structuring of research networks."

theoretically intended to promote firm-level innovation simply adopt criteria better suited to academic proposals owing to the evaluators already being acquainted with the procedures.

The difficulty of assimilating the Systemic Model is expressed by Pacheco (2005, p. 20) as follows:

> *The players have little understanding of the systemic nature of these public policies or of the complementary nature of the investments required. Curiously, an academic bias can be observed not only in the demand for resources and requests for support of universities and post-graduate studies, but also in the suggestions for policies in support of the private sector. In Brazil, proposals, including those in support of industry, are often formulated from the perspective of academic research: financing for activities with no immediate returns, grants for investment in human resources, and holding the public sector responsible for promoting private sector research activities.* [In contrast], *little advance has been made in relation to placing typically economic or industrial policies on the agenda, such as offering new credit lines and supporting firms in their efforts to internationalize, acquire certification, or improve their products and/or processes.*

Beyond what Pacheco terms "academic bias", other obstacles exist to the implementation of innovation policy due to the fact that its nature differs from that of the previous policy, as do its primary agents and proposals. Whereas traditional S&T policies involve mainly public universities and research institutes, innovation policies center on enterprises; and different from learning and research institutions, whose main objectives are to form human resources and produce scientific articles, enterprises produce and commercialize goods and services in order to earn profit. Whether owing to this difference in nature or to long institutional practice, it is easy for public agencies to deal with, support and stimulate learning and research institutions, but extremely hard for them to interact with enterprises in a similar manner. This difficultly has marked the efforts to implement policy instruments specifically aimed at promoting innovation, such as offering subsidies or requisitioning innovative products and processes.

The problems involved in implementing innovation policy became highly evident during the 2006 Innovation and Jurisprudence Seminar sponsored by the Industrial Federation of the State of São Paulo (FIESP) and the Center for Strategic Management and Studies (CGEE). During the seminar, the problems faced by both policy administrators and corporate managers were discussed (CGEE 2007). All feel the lack of a regulatory net enabling them to safely take advantage of the opportunities offered by the new innovation policy. Given that certain clauses of the existing legislation are quite restrictive, those responsible for implementing the policies face the risk of legal exposure. By way of example, government purchases are rigorously subject to the lowest price law, thus making it nearly impossible to use the purchasing power of the government as a tool to stimulate innovation. In this case, recommending that the government purchase an item — even one authorized under the new Law of Innovation — might attract the attention of an inspection agency and lead to cancellation of the purchase or even condemnation of those who requisitioned it. Another example refers to the legal limits of the new fiscal incentive

legislation, since from the legal standpoint, a consensus has not yet been reached as to which types of R&D and innovation activities have the right to incentives.

Suzigan and Furtado's (2006) evaluation of the industrial, technological and trade policy (PITCE) implemented during the period 2003-2006 was harshly critical:

> *Although* [PITCE] *has certain positive aspects, such as its focus on innovation, clearly defined goals and new institutional organization, it fails as a development policy due to weaknesses such as its lack of compatibility with macroeconomic policy, lack of consistency among its policy instruments, weaknesses in the infrastructure and overall system for science, technology and innovation, lack of coordination and lack of political will.* (Suzigan and Furtado 2006, p. 163)

In spite of believing that the majority of instruments necessary to the innovation policy have already been created (as already indicated), Arruda, Vermulm and Hollanda (2006, p. 109) are also highly critical as to the management of the policy:

> *What has been observed to date is a great lack of organization in relation to the execution of policy measures in the area of science, technology and innovation. The financial resources available are far from sufficient and allocated in an unplanned, pulverized way, thus making it impossible to achieve the structural change necessary. On the one hand, the private sector lacks the technological capabilities required to transform* [Brazil] *into a more dynamic industrial economy on the basis of innovation; on the other, if this is to happen, the public sector will have to participate in a proper and more competent manner.*

Awareness of these obstacles to the effective implementation of the innovation policy leads to the conclusion that much is yet to be done for the policy to bear significant fruit. Overcoming the limitations imposed by these obstacles will unquestionably require much time and energy.

The great number of measures, initiatives and guidelines that currently exist need to converge to a more reduced and manageable set of strategic priorities and goals, and simultaneously it is also necessary to recover the country's capability for planning and coordinating long term actions and policies.

In addition, the lack of coordination and synergy among the various institutions in charge of carrying out innovation policies also compromise their efficacy. The need for coordination applies not only to the institutions typically linked to innovation, but also to other institutions, as well as to other governmental spheres and their extensions. In this regard, it is worth calling attention to the fact that there is little need for coordination when a policy is focused exclusively on research (especially basic research) or on the formation of human resources, since these two areas are subject to vertical relations with typical S&T institutions. In the case of true innovation policy, however, the situation is considerably different, given that the innovations are in areas not typical of traditional S&T policy, such as agriculture, industry, defense, health and telecommunications. Hypothetically, for example, it is of little use to develop a technology in the field of telecommunications if its

utilization is neither permitted nor validated by the sector regulation. At the same time, the success of many innovations depends on measures or decisions relating to government purchases, taxes, financing, tariffs, sanitary controls, biological safety or environmental controls, none of which are within the sphere of S&T. For this reason, the need for coordination becomes absolutely essential when the question is one of transition from traditional S&T policies to innovation policies.

While the definition of a reduced set of strategic objectives facilitates coordination, it will also be necessary to restructure and qualify the institutional apparatus in order to improve its ability to deal with the very process of priority setting, exercising coordination, evaluation and executing plans and policies. Within this perspective, some institutions were created, one being the Brazilian Agency for Industrial Development (ABDI). As a rule, however, these institutions have proven fragile and ill-prepared for the demands placed on them. Consequently, they need to be strengthened and/or restructured. The restructuring and qualification of the National Industrial Property Institute (INPI) currently underway is a step in the right direction. However, other institutions such as the very Ministry of Science and Technology (MCT), its Financing Agency for Studies and Projects (FINEP), the National Council for Scientific and Technological Development (CNPq) still have much to do in order to become adapt and qualified for the effective implementation of a innovation policy.

It must be recognized, however, that, *a priori*, no institutions, instruments or even policies are ideal for the promotion of innovation. Nor are there international models that can be copied in their entirety, for the model should be constructed in accordance with the historical conditions and the strategic needs of the country in question. What international experience does reveal, however, is that successful models reflect a continuous effort to adapt, learn from and improve the policies involved; in other words, they have built-in mechanisms for "policy learning" (OECD 2005). In fact, at the present stage of Brazilian ST&I policy, any advance in the direction of "a policy that learns" would be most opportune, the reason being that the it is currently marked by a certain degree of experimentalism where numerous approaches, programs, plans, policies, instruments and measures are being tested, but they are not always interconnected nor do they always reflect the priority that the new policy ascribes to innovation.[37]

One of the factors that makes a policy intelligent and enables it to learn from experience is the existence of an evaluation system. In this respect, much remains to be done in Brazil. Among the systems in operation in the country, that which provides feedback to CAPES stands out for its capacity to guide higher learning and research and inform the general public. However, most of the existing monitoring systems are overly focused on evaluating individual projects *a priori*, an activity which is evidently of limited value in terms of bettering policies. For this purpose, it is essential to improve the assessment of policies, plans, programs, tools and measures in general. Moreover, such assessments must be

[37] This is evident from the "menu" of possibilities offered on the Internet by federal ministries, state secretariats, regulatory agencies, financing agencies and other entities directly or indirectly involved in ST&I.

conceived and employed with a view to reformulating and improving policies, without being allowed to become an end in themselves.

The ongoing efficacy of an innovation policy depends, however, on far more than modifying and improving the regulations, management and institutional framework of the policy. The seeds of innovation must be planted on fertile ground; and for this to occur, the learning and research institutes, and, above all, the enterprises involved, must be adequately prepared.

Achieving the desired transformation of learning and research institutions goes beyond relaxing the regulations that guide them and setting up technology transfer centers for intellectual property protection and commercialization, as prescribed by the Law of Innovation. It is also of vital importance to modernize graduate and postgraduate courses by updating their curricula in such a way as to prepare their students also to engage in technological innovation.[38] Even at the postgraduate level, which has excellent credentials in terms of growth, diversification and quality, more has to be done to meet the demands of a market that should be less concentrated in the universities themselves, research institutes and public administration.[39] In other words, technological change and innovation, both current and projected, should play a more important role in determining the development of Brazilian postgraduate programs.

At the same time, Brazilian enterprises generally have little familiarity with innovation;[40] and when they have passive technological strategies or lack the capacity for active technological learning and innovation, as is the case of the majority of Brazilian industrial enterprises,[41] the efficacy as well as the efficiency of the stimuli offered by innovation policies is evidently compromised, not to mention the ability of the enterprises to help

[38] There are indications that Brazilian PhDs are directly contributing far less than possible to firm-level innovation. The Brazilian Innovation Survey (PINTEC) estimated, for example, that less than 3 thousand workers with postgraduate degrees were engaged in R&D activities at innovative firms in 2000, a year in which Brazilian universities conferred 18 thousand Master's and 5 thousand doctoral degrees (Viotti et al. 2005). Regarding this subject, also see Viotti and Baessa (2008).

[39] According to Viotti and Baessa (2008), of the almost 26 thousand Brazilians who received doctoral degrees in the period 1996-2003 and were formally employed during 2004, 65.96% were working in the educational sector, 18.27% in public administration, defense or social security, and only 1.24% in industrial manufacture.

[40] Viotti (2205 and 2007) offers a relative idea of how limited innovation is in Brazil by comparing the innovative performance of Brazilian industrial enterprises to that of Argentine and European enterprises. The comparison is based on data from the Brazilian innovation survey (PINTEC 2000) and the third round of the surveys conducted by the European Community (CIS-3).

[41] The concepts of passive and active technological learning, as differentiated from innovation, were introduced by Viotti (1997 and 2002) and further elaborated in a subsequent work (Viotti 2004). Empirical data indicating that the passive technological learning strategy prevails among Brazilian industrial enterprises are to be found in Viotti (2005 and 2007).

shape the very policies that affect them. This limitation is mainly due to the history of Brazilian industry, the structure of the enterprises and the macroeconomic environment in which they operated or operate. Factors linked to the structure of the productive sector also condition or limit the innovation process of the country as a whole. For instance, there are relatively few Brazilian enterprises in the more technologically dynamic sectors, which tend to be led by foreign enterprises,[42] and few Brazilian undertakings are competitive in global markets. Thus, policies, business strategies and the domestic enterprises themselves all need to be redirected towards restructuring the productive sector so as to make it more favorable for innovation.

Undoubtedly, the macroeconomic environment is among the factors that most strongly influence the productive structure and the propensity to innovate. Although changing this environment is a task of historic proportions, it is one that the country must undertake. During the import substitution period, the industrial sector was essentially committed to absorbing productive capacity, which is associated with passive technological learning. Thereafter – during the last two decades of the 20th century and the first years of the 21st century – the macroeconomic environment was hostile to investment, and especially to the type of investment that involved risk or was of a long-term nature, such as investment in innovation.

Fortunately, however, the last few years have been ones of significant progress in the Brazilian macroeconomic scenario. Among the advances witnessed are the substantial reductions in the external vulnerability of the economy, in the volatility of prices, in the near chronic instability of the economy and in the resulting lack of predictable horizons, all of which formerly led to a short-term outlook and defensive strategies, which, in turn, discouraged investment.

Even so, the investments so vital to innovation are still extremely limited. The historic dimension of the challenge represented by the need to recover the overall investment levels of the economy becomes clearly visible on analyzing the evolution of the rates of investment in Brazil. The average rate of investment stood at 21.6% of GDP in the 1970s; 22.2% in the 1980s; fell to 18.2% in the 1990s; and then dropped to a mere 16.4% in the period 2000-2007. It was still very low during 2007 when it achieved 17.6%,[43] but it is relevant to note that the growth of investment has been sustained during the last three years. These level of investment seem to be incompatible with any strong process of development and this fact becomes obvious when they are compared with those of economies on the catching-up path, such as China, where the rates over the last several years have approached 40% of GDP. For the rates of investment to rise and the economy to grow at a

[42] Viotti and Baessa (2007, p. 223) have found indications that the foreign enterprises in Brazil are less innovative in technologically advanced sectors (which they dominate) than in more traditional sectors. In turn, Araújo (2005) has found evidence that firm size, sectoral distribution, etc., having been controlled for, the foreign enterprises in Brazil invest significantly smaller proportions of their turnover in R&D than do the domestic enterprises.

[43] These data were computed from information presented in the table "Taxa de Investimentos a Preços Correntes – % do PIB", updated on 12 March 2008 (http://www.ipeadata.gov.br).

faster pace, hence allowing for more vigorous innovation efforts, the current interest rates, as well as the now overvalued exchange rate, will have to be substantially lowered.

In spite of the magnitude of the task of framing a macroeconomic environment capable of stimulating innovation, the structural conditions are now incomparably more favorable than they were in recent decades. The stability of the economy and the democratic process have apparently been consolidated. As a result of this stability and recent social policies, the domestic market is in frank expansion. The current energy crisis is not likely to have the shattering impact on the growth of the country that former crises had; on the contrary, Brazil appears to be in a position to benefit from the crisis due to promising opportunities for its ethanol and oil output. The country is now in the technological lead in relation to the production and use of ethanol for fuel-combustion engines, an application which helps reduce the emission of gases that contribute to the greenhouse effect. In addition, the country has become self-sufficient in oil and has recently discovered new superfields. Lastly, Brazil is in an excellent position to benefit from the rapid growth of the world demand for food, as well as from the spiraling prices for food and mineral products.

This alignment of the stars in the world economy in favor of Brazil clearly represents a window of opportunity for the framing of a successful development policy. The greatest challenge facing the country is not to become complacent in the face of the passing bonanza, but to take advantage of this historic opportunity to implement a set of active policies to anchor the growth and development of the country on competitive advantages based on technological advantages rather than on the unsustainable exploitation of natural resources and cheap labor. In other words, the greatest challenge facing Brazil is to transform S&T policy into an effective innovation policy and convert it in the basis for the new development policy.

References

ABDI. 2007. *Resumo da PITCE.* Brasília. (March). http://www.abdi.com.br/abdi_redesign/publicacao/download.wsp?tmp.arquivo=400.

_____. 2006. *Balanço da PITCE 2005*. Brasília. (April 4). http://www.desenvolvimento.gov.br/arquivo/ascom/imprensa/20060404balancoPITCE.pdf (accessed November 27, 2007).

Anprotec. 2006. *Panorama de Incubadoras de Empresas e Parques Tecnológicos 2006.* http://www.anprotec.org.br/ArquivosDin/Graficos_Evolucao_2006_Locus_pdf_59.pdf.

Araújo, Rogério Dias de. 2005. "Esforços Tecnológicos das Firmas Transnacionais e Domésticas." In *Inovações, Padrões Tecnológicos e Desempenho das Firmas Industriais Brasileiras*, ed. J. A. De Negri and M. S. Salerno, 119-70. Brasília: Ipea.

Arruda, Mauro, Roberto Vermulm and Sandra Hollanda. 2006. *Inovação Tecnológica no Brasil: A Indústria em Busca da Competitividade Global*. São Paulo: Anpei. http://www.anpei.org.br/download/estudo_anpei_2006.pdf (accessed June 10, 2007).

Arundel, Anthony. 2006. "Innovation Indicators: Any Progress Since 1996? Or How to Address the 'Oslo Paradox'." Paper presented at the II Blue Sky Conference: What Indicators for Science, Technology and Innovation Policies in the 21st Century, organized by the OECD, NSF and Industry Canada, Ottawa, September 25-27. http://www.oecd.org/dataoecd/24/28/37436234.pdf [Also available in OECD. 2007, Chapter 4].

Arundel, Anthony and Hugo Hollanders. 2006. "Trend Chart Methodology Report – Searching the Forest for the Trees: 'Missing' Indicators of Innovation." Paper presented at the MERIT Conference, organized by the Maastricht Economic Research Institute on Innovation and Technology, July 1. http://www.proinno-europe.eu/doc/eis_2006_methodology_report_missing_indicators.pdf. (accessed September 30, 2007).

Brasil. Casa Civil, MDIC, MF, MPOG, MCT, IPEA, BNDES, FINEP and APEX. 2003. *Diretrizes de Política Industrial, Tecnológica e de Comércio Exterior (PITCE).* (November 23). http://www.abdi.com.br/abdi_redesign/publicacao/download.wsp?tmp.arquivo=107.

Brasil. Presidência da República, Secretaria de Ciência e Tecnologia. 1991. *A Política Brasileira de Ciência e Tecnologia 1990/95*. 2nd ed. Brasília.

Bush, Vannevar. 1945. *Science – The Endless Frontier: A Report to the President on a Program for Postwar Scientific Research*. Washington, DC: United States Government Printing Office. Reprinted 1990. Washington, DC: National Science Foundation. http://www.nsf.gov/od/lpa/nsf50/vbush1945.htm (accessed September 29, 2007).

CAPES. 2008. "Produção Científica Brasileira É a 15ª em Todo o Mundo." Brasília. (July 8). http://www.capes.gov.br/servicos/salaimprensa/noticias/noticia_0882.html.

_____. 2004. "Plano Nacional de Pós-Graduação (PNPG) 2005-2010." Brasília. (December). http://www.capes.gov.br/opencms/export/sites/capes/download/editais/PNPG_2005_2010.pdf.

CGEE. 2006. Seminário Inovação e Segurança Jurídica: Contribuições ao Debate, São Paulo, December 13, 2006. http://www.cgee.org.br/arquivos/sisj.pdf.

Cimoli, Mario, João Carlos Ferraz and Annalisa Primi. 2005. *Science and Technology Policies in Open Economies: The Case of Latin America and the Caribbean*. UN-ECLAC Productive Development Series 165. Santiago de Chile. (October). http://www.eclac.org/publicaciones/xml/3/23153/DP165.pdf.

Dagnino, Renato, Flávio Cruvinel Brandão and Henrique Tahan Novaes. 2004. "Sobre o Marco Analítico-conceitual da Tecnologia Social." In *Tecnologia Social: Uma Estratégia para o Desenvolvimento*, 15-65. Rio de Janeiro: Fundação Banco do Brasil. http://www.rts.org.br/publicacoes/arquivos/tecnologia_social_uma_estrategia_de_desenvolvimento.pdf

Erber, Fábio Stefano. 1979. "Política Científica e Tecnológica no Brasil: Uma Revisão da Literatura." In *Resenhas de Economia Brasileira*, org. João Sayad, 117-97. São Paulo: Saraiva.

Fajnzylber, Fernando. 1988. "Competitividad Internacional: Evolución y Leciones." *Revista de la CEPAL*, 36(December): 7-23,

Falkenheim, Jaquelina C. 2007. "U.S. Doctoral Awards in Science and Engineering Continue Upward Trend in 2006." National Science Foundation InfoBrief NSF 08-301. (November). <http://www.nsf.gov/statistics/infbrief/nsf08301/nsf08301.pdf (accessed July 4, 2008).

Franco Gustavo H. B. 1996. "A Inserção Externa e o Desenvolvimento." Banco Central do Brasil, Diretoria de Assuntos Internacionais. (June 19). Mimeographed document. http://www.econ.puc-rio.br/gfranco/insercao.pdf. [Published in *Revista de Economia Política*, 18(3): 121-47].

Galvão, Antônio Carlos. 1993. "C&T no Brasil: Avanços e Retrocessos na Década de 80." Brasília. Mimeographed document.

Gibbons, Michael. 1995. "Comments on Science and Technology in Brazil". In *Science and Technology in Brazil: A New Policy for a Global World*, org. Simon Schwartzman, Vol. 1, 57-71. Rio de Janeiro: Fundação Getúlio Vargas.

Guimarães, Eduardo Augusto. 2006. "Políticas de Inovação: Financiamento e Incentivos." Texto para Discussão 1212. Brasília: Ipea. http:/www.ipea.gov.br/sites/000/2/publicacoes/tds/td_1212.pdf (accessed November 27, 2007).

_____. 1996. "A Experiência Recente da Política Industrial no Brasil: Uma Avaliação." Texto para Discussão 409. Brasília: Ipea. http://www.ipea.gov.br/pub/td/1996/td_0409.pdf

IEDI. 2005. "Os Fundos Setoriais de C&T: Desafios e Perspectivas para 2005." *Carta IEDI*, 161 (June 24). http://www.iedi.org.br/cgi/cgilua.exe/sys/start.htm?from%5Finfo%5Findex=161&sid=20&infoid=1293.

INPI. 2008. "Tabela Certificados de Averbação por Categoria Contratual." (March 9). http://www.inpi.gov.br/menu-esquerdo/instituto/resolveUid/cde3cce80d7dd38274b115ae51f03bee.

INPI/MCT. 2007. "Tabela 6.1 – Brasil: Pedidos de Patentes Depositados no Instituto Nacional de Propriedade Industrial (INPI), segundo Tipo e Origem do Depositante, 1990-2006." [Data updated on September 4, 2007]. http://www.mct.gov.br/index.php/content/view/5688.html (accessed March 12, 2008).

ISO. 2001. "Annex A: ISO 9000 Certifications Worldwide: Growth from 1995 to End of 2000." In *The ISO Survey of ISO 9000 and ISO 14000 Certificates – Tenth Cycle: Up to and Including 31 December 2000*, 12-15. Geneva: International Organization for Standardization. http://www.iso.org/iso/survey10thcycle.pdf.

Kupfer, David and Frederico Rocha. 2005. "Productividad y Heterogeneidad Estructural en la Industria Brasileña." In *Heterogeneidad Estructural, Asimetrías Tecnológicas y Crecimiento en América Latina*, ed. Mario Cimoli, 70-100. Santiago de Chile: CEPAL. http://www.eclac.org/iyd/noticias/paginas/4/31434/W35_CIMOLI.pdf.

Lall, Sanjaya, and Morris Teubal. 1998. "'Market Stimulating' Technology Policies in Developing Countries: A Framework with Examples from East Asia." *World Development*, 26(8): 1369-85.

MCT/ABC. 2001. *Ciência, Tecnologia e Inovação: Desafio para a Sociedade Brasileira – Livro Verde*, org. Cylon Gonçalves da Silva and Lúcia Carvalho Pinto de Melo. Brasília: Ministério da Ciência e Tecnologia e Academia Brasileira de Ciências. http://www.mct.gov.br/index.php/content/view/18843.html.

MCT. 2002. *Livro Branco: Ciência, Tecnologia e Inovação*. Brasília: Ministério da Ciência e Tecnologia. http://www.cgee.org.br/arquivos/livro_branco_cti.pdf.

MCT. 2006. *Ministério de Ciência e Tecnologia: Relatório de Gestão 2003-2006*,. Brasília. (December). http://http://agenciact.mct.gov.br/upd_blob/0041/41018.pdf.

MCT. 2007a. *Ciência, Tecnologia e Inovação para o Desenvolvimento Nacional: Plano de Ação 2007-2010 – Investir e Inovar para Crescer*. Brasília. (November). http://www.mct.gov.br/upd_blob/0021/21439.pdf.

MCT. 2007b. "Tabela – Número de Artigos Brasileiros, da América Latina e do Mundo Publicados em Periódicos Científicos Internacionais Indexados no Institute for Scientific Information (ISI), 1981-2006." Brasília. (September). http://www.mct.gov.br/index.php/content/view/8499.html (accessed July 6, 2008).

MCT. 2007c. "Tabela – Brasil: Alunos Novos, Matriculados ao Final do Ano e Titulados nos Cursos de Mestrado e Doutorado, 1987-2006." Prepared on the basis of data from CAPES, Ministry of Education (MEC). Brasília. (August). http://www.mct.gov.br/index.php/content/view/6629.html.

MCT/FNDCT. 2008. "Fundos Setoriais." Brasília. http://www.mct.gov.br/index.php/content/view/725.html#.

OECD. 2005. *Governance of Innovation Systems*. Volume 1, *Synthesis Report*. Paris. http://213.253.134.29/oecd/pdfs/browseit/9205121E.PDF.

OECD. 2006. *Science, Technology and Innovation Indicators in a Changing World: Responding to Policy Needs*. Proceedings of the II Blue Sky Conference, Ottawa, September 25-27. Paris. http://www.oecd.org/document/12/0,3343,en_2649_33703_39369868_1_1_1_1,00.html (accessed September 30, 2007).

Pacheco, Carlos Américo. 2005. "Políticas Públicas, Intereses y Articulación Política: Cómo se Gestaron las Recientes Reformas al Sistema de Ciencia y Tecnología en Brasil." Serie Politicas Sociales 103. Santiago de Chile: CEPAL.

http://www.eclac.cl/publicaciones/xml/8/20848/sps103_lcl2251.pdf

Pacheco, Carlos Américo. 2007. "As Reformas da Política Nacional de Ciência, Tecnologia e Inovação no Brasil (1999-2002)." Santiago de Chile: CEPAL. http://www.cepal.org/iyd/noticias/paginas/5/31425/carlosamericop.pdf

Pereira, Newton Müller. 2005. "Fundos Setoriais: Avaliação das Estratégias de Implementação e Gestão." Texto para Discussão 1136. Brasília: Ipea. http://www.ipea.gov.br/pub/td/2005/td_1136.pdf

Salerno, Mario Sergio, and Talita Daher. 2006. "Política Industrial, Tecnológica e de Comércio Exterior do Governo Federal (PITCE): Balanço e Perspectivas." Brasília: ABDI. Mimeographed document.

Sarti, Fernando., and Rodrigo Sabbatini. 2003. "Conteúdo Tecnológico do Comércio Exterior Brasileiro." In *Indicadores de Ciência, Tecnologia e Inovação no Brasil*, ed. E. Viotti and M. Macedo, 377-422. Campinas: Editora da Unicamp.

Schwartzman, Simon et al. 1995a. *Science and Technology in Brazil.* Vol. 1, *A New Policy for a Global World.* Rio de Janeiro: Fundação Getúlio Vargas.

http://www.schwartzman.org.br/simon/scipol/summ1.htm.

_____. 1995b. *Ciência e Tecnologia no Brasil.* Vol. 2, *Política Industrial, Mercado de Trabalho e Instituições de Apoio.* Rio de Janeiro: Fundação Getúlio Vargas. http://www.schwartzman.org.br/simon/scipol/summ2.htm.

_____. 1996a. *Ciência e Tecnologia no Brasil.* Vol. 3, *A Capacitação Brasileira para a Pesquisa Científica e Tecnológica.* Rio de Janeiro: Fundação Getúlio Vargas. http://www.schwartzman.org.br/simon/scipol/summ3.htm.

_____. 1996b. *Science and technology in Brazil: a new policy for a global world*. In Simon Schwartzman (org.) Science and technology in Brazil: a new policy for a global world, (Vol. 1) Rio de Janeiro, Fundação Getúlio Vargas, 1995, pp. 1-56. <www.schwartzman.org.br/simon/scipol/newpol.htm>

Stokes, Donald E. 1997. *Pasteur's Quadrant: Basic Science and Technological Innovation.* Washington, DC: Brookings Institution Press.

Suzigan, Wilson and João Furtado. 2006. "Política Industrial e Desenvolvimento." *Rev. Econ. Polit.*, 26(2): 163-85. http://www.scielo.br/pdf/rep/v26n2/a01v26n2.pdf. [Published in English in *CEPAL Review*, 89(August): 68-84 and in Spanish in *Revista de la CEPAL*, 89(August): 75-91].

Thurgood, Lori, Mary J. Golladay and Susan T. Hill. 2006. "U.S. Doctorates in the 20th Century". National Science Foundation Special Report. (June). http://www.nsf.gov/statistics/nsf06319/pdf/nsf06319.pdf (accessed July 4, 2008).

USPTO. 2007. "Extended Year Set – Historic Patents by Country, State, and Year: Utility Patents Granted 01/01/1963–12/31/2007." Patent Technology Monitoring Team Report (December). http://www.uspto.gov/web/offices/ac/ido/oeip/taf/cst_utlh.htm (accessed April 6, 2008).

Vermulm, Roberto, and Tomás Bruginski de Paula. Forthcoming [2006]. *A Política Tecnológica no Brasil e a Experiência Internacional*. São Paulo: IEDI.

Viotti, Eduardo B. and Adriano Baessa. Forthcoming [2008]. *Características do Emprego dos Doutores Brasileiros: Características do emprego formal no ano de 2004 das Pessoas que Obtiveram Título de Doutorado no Brasil no Período 1996-2003*. Brasília: CGEE.

Viotti, Eduardo B., and Adriano Baessa. 2007. "Innovation in Brazilian, Argentine and European Industries: A Comparison of Innovation Surveys." In *Technological Innovation in Brazilian and Argentine Firms*, ed. João Alberto De Negri and Lenita Turchi, 223-44. Brasília: Ipea. http://www.ipea.gov.br/sites/000/2/livros/technological_innovation_ingles.pdf

Viotti, Eduardo B., A. Baessa and P. Koeller. 2005. "Perfil da Inovação na Indústria Brasileira: Uma Comparação Internacional." In *Inovação, Padrões Tecnológicos e Desempenho das Firmas Industriais Brasileiras*, org. Mario S. Salerno and João Alberto De Negri, 653-87. Brasília: Ipea. http://www.ipea.gov.br/sites/000/2/livros/Inovacao_Padroes_tecnologicos_e_desempenho.pdf.

Viotti, Eduardo. 2004. B. "Technological Learning Systems, Competitiveness and Development." Texto para Discussão 1057. Brasília: IPEA. http://www.ipea.gov.br/pub/td/2004/td_1057.pdf.

Viotti, Eduardo B., and Mariano de M. Macedo. 2003. "Indicadores de Ciência, Tecnologia e Inovação: Uma Introdução." In *Indicadores de Ciência, Tecnologia e Inovação no Brasil*, ed. E. Viotti and M. Macedo, 19-39. Campinas: Editora da Unicamp.

Viotti, Eduardo B. 2002. "National Learning Systems: A New Approach on Technical Change in Late Industrializing Economies and Evidences from the Cases of Brazil and South Korea." *Technological Forecasting and Social Change*, 69: 653-80.

Viotti, Eduardo B. 1997. "Passive and Active National Learning Systems." PhD diss. The New School for Social Research, New York.

Williamson, John. 1990. "What Washington Means by Policy Reform." In *Latin American Adjustment: How Much Has Happened?* ed. J. Williamson. Washington, DC: Institute for International Economics.