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The volatility of S&T policy agenda in Brazil

Victor Pelaez
Universidade Federal do Paraná / Programa de Pós-Graduação em Políticas Públicas
Curitiba / PR — Brazil

Noela Invernizzi
Universidade Federal do Paraná / Programa de Pós-Graduação em Políticas Públicas
Curitiba / PR — Brazil

Marcos Paulo Fuck
Universidade Federal do Paraná / Programa de Pós-Graduação em Políticas Públicas
Curitiba / PR — Brazil

Carolina Bagatolli
Universidade Federal do Paraná / Programa de Pós-Graduação em Políticas Públicas
Curitiba / PR — Brazil

Moacir Rodrigues de Oliveira
Controladoria-Geral da União do Estado do Paraná
Curitiba / PR — Brazil

In the 1950s, Brazil first made science and technology (S&T) an explicit item on its federal policy agenda. The international crises of 1970s interrupted the expansion of public investment in the area. Following 2000, relative macroeconomic stability brought back industrial policies based on systemic approaches to innovation. However, S&T policies initiatives have been overcome by the ongoing macroeconomic crisis and the governments' incapability to maintain the macroeconomic stability. This paper discusses Brazil's S&T policy track record, taking into account institutional path dependence that has held back the orchestration of a long term development model.
Keywords: S&T; policy; agenda; Brazil; innovation.

A volatilidade da agenda de políticas de C&T no Brasil

Foi na década de 1950 que o Brasil incluiu explicitamente o item Ciência e Tecnologia (C&T) na agenda política em nível federal. As crises internacionais da década de 1970, entretanto, interromperam o avanço dos investimentos públicos nessa área, que acabaram sendo retomados nos anos 2000 com políticas industriais baseadas em concepções sistêmicas de inovação, a partir de um cenário de relativa estabilização macroeconômica. Contudo, a recente crise financeira internacional e a incapacidade dos governos de manter a estabilidade macroeconômica têm restringido a ação de políticas de C&T. O objetivo deste artigo é resgatar a trajetória da agenda das políticas de C&T no Brasil, considerando a dependência de caminhos institucionais que têm retardado a construção de um modelo de desenvolvimento de longo prazo.
Palavras-chave: C&T; políticas; agenda; Brasil; inovação.

La volatilidad de la agenda de políticas de C&T en Brasil

A partir de los años 1950 políticas explícitas de C&T fueron incorporadas a la agenda de los gobiernos federales en Brasil. Las crisis internacionales de la década de 1970 interrumpieron las inversiones públicas en el área. En los años 2000, una relativa estabilización macroeconómica llevó a retomar las políticas industriales basadas en concepciones sistémicas de innovación. Con todo, la reciente crisis financiera internacional y la incapacidad de los gobiernos para mantener la estabilidad macroeconómica han restringido la acción de las políticas de C&T. El objetivo de este artículo es rescatar la trayectoria de la agenda de las políticas de C&T en Brasil, a partir de los caminos de dependencia institucional que han retardado la construcción de un modelo de desarrollo de largo plazo.
Palabras clave: C&T; políticas; agenda; Brasil; innovación.

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1. INTRODUCTION

In the 1950s, Brazil first made science and technology an explicit item on its federal policy agenda, in a in an attemp to promote development through import substitution. The steep decline of international liquidity that followed the second oil crisis and the escalating interest rates in the United States interrupted the expansion of the Brazilian public investment in the area, whose peak in 1978 had only been surpassed 30 years later. Following 2000, relative macroeconomic stability brought back industrial policies based on systemic approaches to innovation in sectors deemed to be strategic. Efforts since then have sought to combine laws that create incentives for innovation with less red tape and greater mobility of human and financial resources between academia and industry.

Science and technology (S&T) policy analyses have mostly focused on issues regarding the content and effects of the mechanisms or institutions that stimulate or hinder technological innovation. Much less discussed are the S&T policy agenda setting dynamics, its historical context, the actors involved and the mechanisms that facilitate or impede its implementation (Edler and James, 2015).

This paper intends to contribute to fill this gap by retracing the trajectory of Brazil's science and technology (S&T) policy agenda setting. It is taking into account institutional path dependence that has held back the orchestration of a more economically, socially and environmentally sustainable development model. This presentation covers three periods, in order to provide a historical outlook on the main points of institutional continuity, rupture, progress and setbacks observed throughout the evolution of S&T policies: (i) from 1950s through the 1970s, when major policies and institutional steps were taken following the adoption of an import-substitution development model; (ii) from 1980s to early 2000s, a period characterized by the prevalence of a long-lasting macroeconomic crisis, and the rise of liberal approaches that simply took industrial policy off the federal government's agenda; and (iii) from 2003 on, a phase which starts with President Lula's first administration, distinguished by the renewal of industrial policies, which are nonetheless subordinated to ongoing macroeconomic policies that restrict risk investments in technological innovation.

Based on literature review on the S&T policies implemented in the country since the 1950s, this work reinterprets the three mentioned historical periods in order to demonstrate the existence of an inherent instability or volatility in Brazilian S&T agendas. Such volatility is explained in terms of systemic policy implementation failures, mostly due to institutional path dependency originated in a linear model of innovation.[1]

To highlight the S&T agenda instability, three indicators are used: the evolution of the federal expenditures in S&T having as proxy the investments of the National Science and Technology Development Fund (FNDCT), and the Funding Authority for Studies and Projects (Finep), as they represent about 55% of this budget (Siafi, 2015); the reports of the Federal Accounts Court (TCU) concerning the management of FNDCT's resources; and the terms of Office of S&T Ministers, responsible for proposing policies in this domain.

Our approach to these policies is neo-Schumpeterian because they focus on technological innovation, as the core of economic development. Moreover, S&T and industrial policies have overlapping objectives, especially when using a systemic approach to the process of innovation. We recognize the

[1] The linear model of innovation presupposes a sequential and cumulative process of knowledge creation, which starts in research activity, is followed by technological development, serial production, till its commercialization (Kline and Rosenberg, 1986).

existence of a gamut of players, organizations and institutions that interact to generate and disseminate new technologies. By adopting an evolutionary approach of the S&T policy agenda setting, we also consider using John Kingdon's model of multiple streams to interpret such evolution as an historical interactive process of problem posing, policy actions and political decision making.

The second section of the paper presents a brief review of innovation systems literature, by emphasizing systemic failures as instruments of diagnosing the complex interactions between heterogeneous actors and mechanisms (institutions) of action. This literature is complemented by John Kingdon's multiple streams approach, which offers elements of analysis for the discussion surrounding the evolution of S&T policy agenda. The third, forth and fifth parts deal with the three different periods identified above, in which a contextualized analysis of the evolution of the S&T agenda is carried out.

2. THE INNOVATION SYSTEM AND THE MULTIPLE STREAMS APPROACHES

Kingdon (1995:3) defines a public policy agenda as: "the list of subjects or problems to which governmental officials, and people outside of government closely associated with those officials, are paying some serious attention at any given time." In this interactive context of key actors in the decision making process, the maintenance and implementation of an S&T policy becomes a greater challenge due to the heterogeneity of the knowledge fields and of interests involved. Technological innovation is presented as a common denominator able to justify and allocate investments in emergency areas (health, education, macroeconomic stability, security) in the sense of promoting economic growth. The systemic view of innovation seeks to, if not provide a solution, diagnose the institutional coordination of countries that succeeded in the allocation of S&T resources. In such a context, there is no ideal model to be followed, but singularities or experiences of different historical realities are to be apprehended (Nelson, 1993; Archibugi and Michie, 1997; Edquist and Hommen, 2008).

The systemic approach presupposes the existence of coordination failures of heterogeneous elements that composes the system. Such failures would be corrected through the creation and implementation of S&T policies. The existence and viability of such policies justly presupposes the elaboration and adaptation of an agenda that mobilizes actors and resources in a coordinated way. This capacity is directly related to institutional alternatives foresaw or architected in order to create new paths or to overcome institutional barriers (path dependence). Woolthuis and partners (2005) identify four types of systemic failures: (i) *infrastructura*l, resulting from insufficient investment in physical infrastructure of S&T; (ii) *institutional*, related to insufficient formal institutions (technical standards, regulation, legislation) and informal ones (values, culture) able to create a stimulating environment for innovation; (iii) *interaction*, in which the creation of social networks is compromised, either by the rigidity of relational structures which avoids new social arrangements, or by the absence of complementary connections that allows a productive diversity; and (iv) *capabilities,* related to the absence of competences to identify new productive opportunities.

Weber and Rohracher (2012) propose a complement to this typification by focusing, not on the structure, but on the transformation possibilities of the system: (i) *directionality failure*, when the capability of idenfying the main problems of society is nonexistent; (ii) *demand articulation failure*, related to the lack of coordination of different potential users of new technologies; (iii) *policy coordination failure*, refers to the lack of public policy coordination, at horizontal level (economics, health, transports, energy) or at vertical (national, regional, local); and (iv) *reflexivity failure*, due to

the incapacity to monitor and anticipate crisis and changes as well as to involve actors into processes of self governance.

The correction of all these failures depends, at first, on public sector entrepreneurship, concerning the mobilization of public and private actors around a common agenda. In analogy to private entrepreneurship Leyden and Link (2015) consider public or political entrepreneurship as the ability to identify unexplored opportunities whose results are uncertain. In a systemic context of innovation, the authors highlight the political entrepreneur as a network broker of actors involved in creative activities.

Kingdon (1995) discusses more elaborately the importance of the public sector entrepreneurship in its multiple streams approach. He is concerned with explaining why some subjects become part of the governmental agenda and others not. Therefore, he performs an analysis based on the combination of three dynamic streams. The *problem stream* corresponds to a set of subjects selected by the authorities. Kingdon considers the problems as social constructions or interpretations of experienced situations, which are identified as relevant by the actors engaged in public policies. The *policy stream*, can be understood as a debugging of communities experts analysis, often resulting from controversial pathways. The experts' discussions can involve public debates in the media and/or at the academic level, in which the ideas tend to be (re)combined, remembered or recycled at different moments. In the *political stream*, there are three factors that influence the agenda setting. The first is the *national mood* that translates the perception of public opinion favorable to assimilate a certain way in which the problems are being formulated. The second is composed of organized political forces, generally exerted by pressure groups in the rooms of decision making. The third factor is related to the very government turnover (administration offices, congressional positions).

The agenda setting movement, which permits the appearance of new public policies, generally occurs in occasions where there is a coupling of these different streams (problems, solutions and political deals). Such a convergence represents a policy window or a favorable opportunity to be used by those who have been advocating for a certain cause. Inspired by Schumpeter, Kingdon identifies an opportunistic behaviour, adopted by individual or collective actors, as a political entrepreneurialism. These entrepreneurs can act at least in three different conjunctures: when they look for the recognition of a problem that concerns them, by exerting pressure to insert it in the agenda; when they promote their envisaged solutions, by means of persuasion or by reducing the resistance against the ideas proposed; or when they promote or take advantage of the streams connections, by tying together their proposals and solutions at the proper moment through the identification of opportunity windows in the agenda setting.

3. THE PROTECTIONIST PHASE: 1950S — 1970S

From the 1950s to the 1970s Brazil inaugurated its research and teaching infrastructure. Of particular importance was the creation of two major funding agencies founded in 1951: the National Research Council (CNPq) and the Coordination for the Improvement of Higher Education Personnel (Capes). Both agencies expanded their reach in the 1960s, as science and technology training dovetailed with the military regime's policies anchored in its "security and development" doctrine. In 1968, the government's Strategic Development Plan (*Plano Estratégico de Desenvolvi-*

mento, PED) made S&T an object of public policy. That same year, Congress passed the University Reform Law, which brought in the North American model for higher education, prioritizing research and graduate studies and requiring full-time dedication by university professors (Longo and Derenusson, 2009).

The FNDCT was set up under the PED in 1969 to fund science and technology development projects and programs. The Finep, a public corporation founded in 1967, took responsibility for the FNDCT. Ever since then, the combination of Finep and FNDCT resources has been the main source of funding for S&T. Initially conceived as a means to support consulting firms, Finep evolved into a pivotal financial support for all phases of science and technology: basic research, applied research, experimental development, economic feasibility studies and final engineering (Longo and Derenusson, 2009).

The emphasis on improving higher education by expanding public universities, however, was not matched by any similar thrust for elementary schools. While illiteracy rates were nearly halved and schooling rates doubled during this period, both remained stable over the following decades. In the 1990s, 18% of Brazilians were still illiterate, and 88% of children from 7-14 years old were enrolled in schools (Schwartzman, Durham and Goldemberg, 1993).

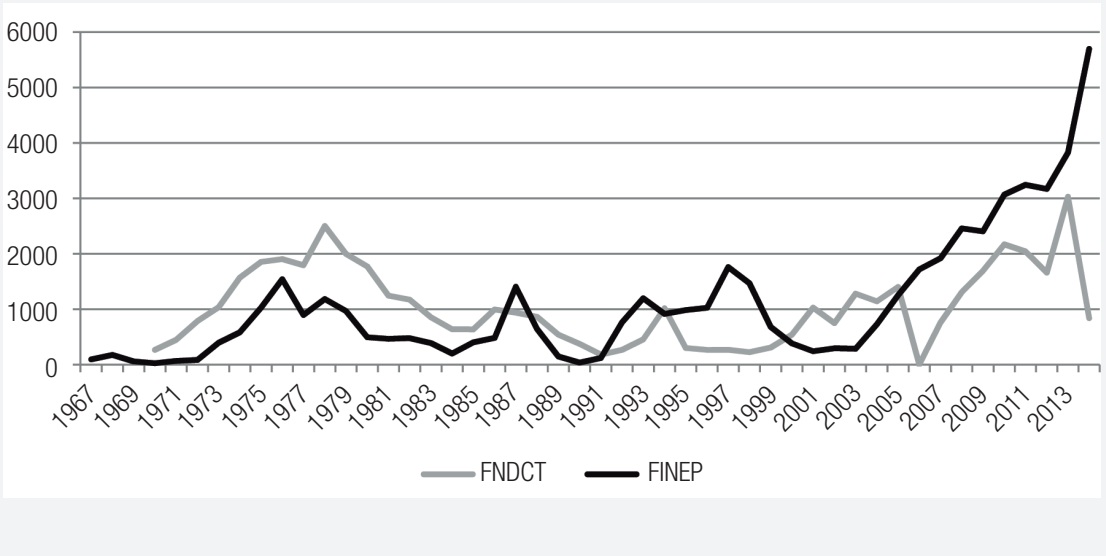
This period also expanded the country's production structures, as part of a series of industrial policy plans, particularly the 2nd National Development Plan (PND) from 1975-79. Its main objective was to consolidate the domestic production of basic inputs, capital goods, food, communications and energy. The import-substitution and export-promotion model was based on attracting investments by multinationals and on creating and supporting state-owned companies in strategic areas such as energy, telecommunications and aeronautics. Those industrial policies raised manufacturing from 16% to 20% of the GDP in the 1970s (FIESP, 2015).

The late 1970s also saw FNDCT's investments peak to levels that would only be repeated 30 years later, after a long period of macroeconomic crisis experienced by Brazil over the next two decades. Likewise, Finep's resources had a marked decrease over the 1980s and 1990s, presenting constant oscillations (graph 1). Indeed, these funds were not originally conceived to have a stable share of federal revenues and were dependent on annual budgets, affected by macroeconomic contingencies (Araújo, 2012).

The main event for agriculture, in this context, was the founding of the Brazilian Agricultural Research Corporation (Embrapa), in 1973. Two decades later, Embrapa coordinated the creation of the National Agricultural Research System, which includes Embrapa, State Agricultural Research Organizations and higher-education research and teaching schools in agrarian sciences. Agricultural research, subsidized farm loans and rural extension were the tripod of agricultural modernization policies, based on the intensive use of chemical, biological and mechanical inputs. The convergence of all these activities placed Brazil among the world's top ten food exporters at the turn of the century, and the second largest in 2011 (FAO, 2014).

Brazilian aircraft manufacturer Embraer was also created during this period (1969), along with research centers including the Petrobras Research Center (1963), the Telecommunications Research and Development Center (1976), and institutions supportive of local producers such as the National Industrial Property Institute (1970), the Brazilian Small and Medium Business Support Service (1972) and the National Metrology, Quality and Technology Institute (1973). Chart 1 lists Brazil's main science and technology support institutions.

GRAPH 1 **EVOLUTION OF FNDCT'S AND FINEP'S YEARLY DISBURSEMENTS, AT CONSTANT AVERAGE PRICES / BASE SEPTEMBER 2015-IGP/DI — R$ MILLIONS**



Source: Araújo (2012); Siafi (2015); Finep (2015).

All the elements produced during those decades for national innovation, however, were not well integrated as a system. The absence of any coordinating mechanisms only compounded the dominant linear approach to innovation, which locks those elements institutionally into a model aimed at creating an innovative and competitive production sector. Industrial and S&T policies, therefore, were not complementary but rather parallel to each other, thwarting the synergies needed to make industries competitive on an international scale. As Suzigan and Furtado (2006:170) put it:

> The state set itself up for economic coordination by creating planning agencies, sectoral goal -oriented programs and plans, institutions and policies for public credit, industrial promotion and foreign trade, with specific norms and regulations on prices, public tariffs, wages, economic concentration, technology transfer, direct foreign investment, etc. Yet the coordination of this institutional framework was, at best, precarious. There was ongoing, indiscriminate and excessive customs protection, indiscriminate fiscal and financial subsidies, belated attention to exports, insufficient attention to capacity building for innovation, and major regulatory distortions regarding investments, public tariffs and wages.

Import-substitution policies, meanwhile, were essentially grounded in a exogenous model of technological development. Industrialized countries' consumption and production patterns were imported in the form of multinationals' manufacturing facilities, many of them already scrapped in their home countries (Tavares, 1978). This accentuated Brazil's social and economic differences and reduced any chances for a technological catch-up more compatible with the reality of an economy marked by high concentration of income.

Nor was there a strategic selection of industrial sectors where domestic production would replace imports. Industrialization was stimulated in all branches of production where it looked feasible in the short term. The role of the state did not emerge from any kind of coordinated planning, but in response to restrictions imposed by overseas markets. When the configuration of forces favorable to domestic industrialization faded, the only way to maintain import-substitution policy was through strong state protection (Herrera, 1975; Hirshman, 1981).

It can be said that between the 1950s and 1970s the consecutive federal government built and maintained an S&T policy agenda able to establish a research and tertiary education infrastructure. In this period, the problem stream was based on an S&T policy conception that did not incorporate the productive sector dynamics. The imports substitution occurred in practice as an *ad hoc* element of the S&T activities. As imported technologies by transnational subsidiaries were already at the end of their life cycle, their adoption would exempt investiments in research and development. The maintenance of this policy was especially possible during the military regime, initiated in 1964, which guaranteed the permanence of technocrat propositions to the extent that politics and public policy streams sustained each other.

The relative success of building S&T infrastructure, with emphasis on third-level education, effectively highlighted systemic failures related to the lack of coordination of education policies that could have led to a greater social inclusion of the population. Also, the emphasis on the implementation of an exogenous consumption model, has restricted even more the possibilities of enlarging the internal market, by revealing a directionality failure of the system elements.

4. THE LIBERAL PHASE: 1980S TO EARLY 2000S

Following the second oil crisis (1979) and the rise in US interest rates, Brazil experienced a major foreign-debt crisis, spiraling inflation and a collapse of its capacity to invest. Any sparse and disperse development planning that did take place had no continuity. Public policy agendas in the 1980s and 1990s revolved around macroeconomic adjustments and economic stabilization.

The Ministry of Science and Technology (MCT), founded in 1985, took responsibility for formulating and coordinating National S&T Policies. The new ministry, however, emerged more as a political feature of Brazil's redemocratization process, in response to long-standing pressure from the scientific community, than as the result of official planning (Buainain, Corder and Pacheco 2014). Despite limited public funding at the time for investment in S&T, the MCT managed to expand research infrastructure in strategic fields of knowledge, through the construction of two technology centers and three national laboratories (chart 1).

Four years later, the ministry was downgraded to a Secretariat under the Ministry of Planning, and then directly subordinated to the President of the Republic. Reinstated as the MCT in 1992, it was led by two successive ministers who actually lasted through the terms of their respective Presidents. That kind of continuity is not at all common for such public posts, and will be further discussed in the next section.

The competitiveness of domestic industry had been compromised by decades of weak industrial policies, not focused on building technological capacity but rather on protecting domestic markets through subsidies and preferential tariffs. Such protectionism, common in many Latin American countries, was also widespread in other regions. In central economies, however, a significant learning

process targeted only the most dynamic sectors, whereas in the periphery protectionism favored all manufacturers indiscriminately — a kind of frivolous protectionism, in Fajnzylber's words (1983). That institutional legacy left ruts of dependency for the practice of protectionist policies, as explained by Suzigan (1996:15):

> The political economy of industrial policies in the 1980s was still bent on extracting revenues from the state. The state's interest was to maintain the *status quo* for macroeconomic adjustment policies and to counter the domestic impact of the international crisis caused by rising international oil prices and interest rates in 1979-80. Restrictions on imports were tightened and export subsidies expanded, as part of the effort to improve the balance of trade.

That protectionist drive only began to be reversed in the 1990s, in a new international context of liberal economic policies. To that end, the 1991 Industrial and Foreign-Trade Policy focused on two complementary aspects: competition and competitiveness. Competition was promoted both through free-trade and anti-trust policies. "Commercial opening," with the reduction or elimination of protectionist tariffs, was strengthened by economic stabilization policies adopted by the Fernando Henrique Cardoso government. Trade liberalization was in harmony with the newly founded World Trade Organization, in 1995, which reoriented official initiatives towards the correction of market failures. Anti-trust measures were organized by Law 8137/1990, on crimes against the economic order, and by Law 8884/1994, which reinvigorated the Administrative Council for Economic Defense (Cade), as a semi-autonomous body associated with the Ministry of Justice. Policies to promote competitiveness, however, had much more limited effects due to the lack of coordination amongst public authorities responsible for producing changes in the country's productive structures (Guimarães, 1996).

Last but not least, many state-owned companies were privatized, particularly those responsible for infrastructure services (electric power, telecommunications, transportation and sanitation). Privatization, a measure required by the International Monetary Fund (IMF) for loans made to Brazil in the 1990s, was a central component in the policy agenda of President Fernando Henrique Cardoso's administration (1995-2002).

That period consolidated an institutional lock-in characterized by a liberal model of governmental management, in the midst a prolonged macroeconomic crisis. Suzigan and Furtado (2010) identified a set of factors blocking the adoption of public policies to promote domestic industry, such as:

i) the impetus of an ideological bias against industrial policies, consolidated over years of dominant liberal economic thought;
ii) macroeconomic policies based on high interest rates and a heavy tax burden, leaving little room to stimulate industrial activity;
iii) public finance for industrial investment was limited by widespread budget cuts, while the National Economic and Social Development Bank (BNDES) prioritized loans for privatizations and had an overriding concern with the financial aspects of its credit operations;
iv) there was no coordination amongst the various policy tools involving competition, regulatory affairs, foreign trade and fiscal incentives.

It was in this context of scarce public resources for S&T that the federal government designed a new funding mechanism for the FNDCT. In 1997, Law 9478 set aside a percentage of royalties from oil exploration to be paid to the National Oil Agency, to support scientific research programs in general and technological development for the oil industry. In addition, by means of Decree 2852/1998, these royalties were destined to FNDCT to be administered by Finep. Those measures were followed by the creation of the Oil and Natural Gas Sectoral Fund, whose success led to the creation of another 16 sectoral funds, 15 of which focus on specific activities.[2] The other two are cross-cutting, one to finance cooperation between universities and corporations (the Green-Yellow Fund) and the other to enhance the infrastructure of S&T institutions (CT-Infra). Except for the Telecommunications Technology Development Fund (Funttel), run by the Ministry of Communication, the other funds' resources are allocated to the FNDCT and administered by Finep. Revenue for these funds comes from a number of fees collected on income from the exploitation of natural resources owned by the Union, as parcels of the Tax on Industrialized Goods (IPI) levied on selected sectors and from the Contribution for Intervention in the Economic Domain (Cide), charged on the amount paid to remunerate the use or acquisition of technological knowledge or technology transfer from abroad.

The creation of these funds allowed the FNDCT to recover its funding capacity, committing stable revenues linked to fees and taxes established by specific laws, as described in table 1. This meant a significant recovery in the FNDCT's volume of resources, which in 2007 — 30 years later — finally surpassed its 1978 budget, with disbursements of approximately R$ 1.5 billion. The 2012 budget actually doubled that figure (MCTI, 2014), demonstrating the growth potential of these funding sources.

Even so, ever since these Sectoral Funds were created, their budgets set by law have undergone systematic cut-backs by all the federal governments, which redirect a significant share of their resources to generate fiscal surpluses. From 1999 to 2005, on the average, 54.7% of FNDCT funds were redirected by the government (see the time series in chart 1).

This period was marked by a restructuring of the problem stream in which the ideology of State intervention, through public investments in S&T, lost room in the federal government agenda. This led to an institutional lock-in in which the lasting economic crisis experienced by the country was cause and effect of the political forces incapacity for recovering investments in S&T. It can be said that the S&T Minister (José Israel Vargas) acted as a political entrepreneur by identifying an opportunity to create funding for S&T investments through the Sectoral Funds. Such an opportunity came from the very privatization process of oil and utility sectors in which charging royalties and additional taxes from incoming capitals were the result of a political bargain to access the public patrimony.

5. ATTEMPTS TO RESTORE INDUSTRIAL POLICIES

In January 2003, President Luiz Inácio Lula da Silva took office, opening prospects for changes in liberal economic policies that had bound Brazil's political agenda under his predecessors. At the outset of his term, he presented a plan called the Industrial and Foreign Trade Policy (Pitce), as part of a new historical context in which industrial policy had already been interconnected with S&T policies. A systemic approach to innovation was already part and parcel of the rhetoric used by policy makers

[2] Oil, Energy, Audiovisuals, Transportation, Water Resources, Mineral Resources, Space, Information Technology, Infrastructure, Aeronautical, Biotechnology, Agribusiness, Health, Amazon and Waterway Transportation.

in these areas. This was also clear in the Pitce's four basic dimensions, aimed essentially at improving Brazil's market competitiveness by stimulating strategic areas of innovation. Those dimensions were: technological development and innovation prioritizing enhancement of the institutional setting; expansion of foreign trade's share in the GDP; industrial and institutional modernization; and greater productive capacity.

To implement the policy, the Brazilian Industrial Development Agency (ABDI) was set up to coordinate relations between federal agencies and the productive sectors. In addition, two new laws were passed to further this same policy agenda. The Innovation Law (Law 10,976/2004) whose main purpose was to facilitate interaction among universities, research institutes and companies, by making it easier for researchers to move from one of these sectors to another. ICTs created since then with ties to the Ministry of Science, Technoloy and Innovation (MCTI) (chart 1) are set up either as private-law legal entities or as public-interest civil-society organizations, in order to reduce the bureaucracy that inhibits cooperation between public and private R&D institutions in Brazil (ABDI, 2011). In 2005, the "Good Law", (11,196/2005, *Lei do Bem*), became the country's main fiscal incentive for innovation, by allowing tax exemptions on corporate investments in R&D.

Despite all this institutional progress, the Pitce did not achieve the desired results, largely because of the dynamics of foreign trade at the time. Following 2000, China's consumption of mineral and agricultural commodities expanded significantly, leading Brazil to reorganize its economy to meet that demand.

During President Lula's second term, a follow-up to the Pitce was launched, known as the Productive Development Policy (PDP). It listed a large number of quantitative targets — in terms of more spending on S&T, fiscal incentives, more exports and more trade surpluses — to be achieved by the end of his term in 2010. During the 2008 international crisis, however, many structural weaknesses that had built up after decades of limited investments in Brazil's manufacturing sectors revealed the low productivity of local industry. Imports of manufactured goods expanded as a result, compromising the maintenance of Brazil's existing production chains (Kupfer, Ferraz and Marques, 2013).

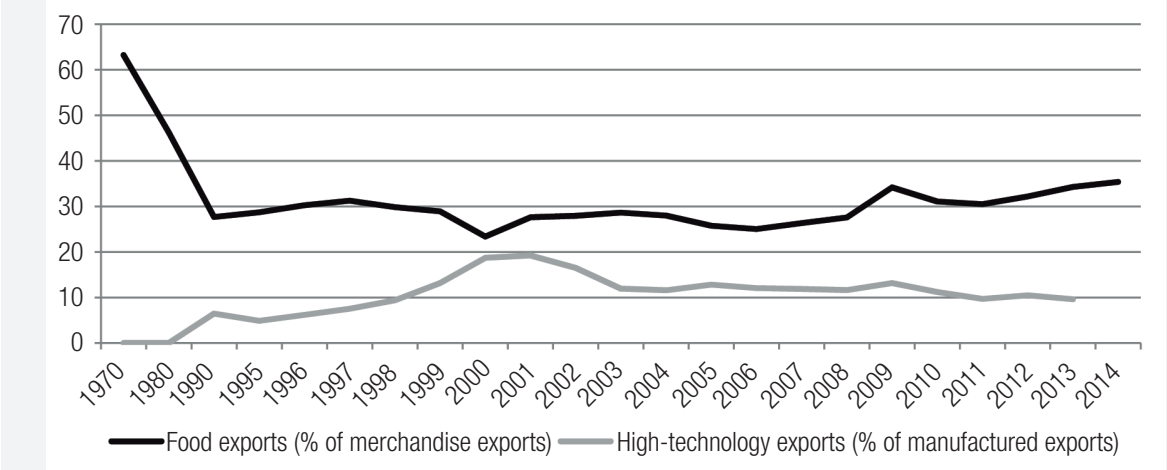
In August 2011, during President Dilma Roussef's first term, the government launched a new industrial, technological and foreign-trade policy, the Greater Brazil Plan (PBM), with the purpose to face the challenges imposed by the country's loss in competitiveness in the international scenario. The PBM reorganized the previous government's plans to coordinate heterogeneous structures throughout the economy, by mobilizing players in five major groups of activities: high-tech intensive, large economies of scale, labor-intensive, services and linked to agribusiness.

That Plan ended up having little or no impact, as Brazil's global market share of international trade continued to slip, falling short of the 1.6% goal for 2013 (ABDI, 2011).[3] It never passed 1.3% (WTO, 2014), the same as it had been since the Plan was launched. The only exception was for agricultural exports, which have expanded significantly since 2000. From 2005 to 2013, Brazil's share of global agricultural exports rose from 6.1% to 7.6% (Mapa, 2014). Meanwhile, the share of agricultural exports in the country's total exports also moved up, from 29.6% to 37.4%. The share of manufactured exports fell, however, from 52.1% to 35.1% (WTO, 2014). This trend is clear in graph 2, which

[3] Since the PBM was launched, Brazil has been falling in the Global Innovation Index, from 47th place in 2011 to 64th in 2013, and then back up to 61st in 2014 (Dutta, Lanvin and Wunsch-Vincent, 2015).

compares the evolution of shares of food over total exports, with the export shares of high-tech over total manufactured products.

GRAPH 2 FOOD AND HIGH-TECH EXPORTS AS % OF MERCHANDISE AND MANUFACTURED EXPORTS (BRAZIL)



Source: World Bank (2015).

Two periods emerge from the time series. First, from 1970-2001, Brazil reduced its share of food exports from 63% to a record low of 23%, while increasing the share of high-tech exports from 6% in 1990 to 19% in 2001. Thereafter, food exports expanded their share constantly, up to 35% of the country's total exports in 2014, while high-tech exports underwent an equally constant fall, down to 9.6% of total manufactured exports in 2013. This trend reveals a "primarization" of the economy, an *a priori* indication of the failure of pro-competitive policies for industry through technological innovation.

Gains in Brazilian agriculture's international competitiveness are to a great extent due to S&T development policies launched in the 1970s, particularly with the creation of Embrapa, whose approach to interaction with the private sector inspired an analogous initiative in 2013, with the founding of the Brazilian Industrial Research and Innovation Corporation (Embrapii). Despite the successful generation and nationwide dissemination of high-performance agricultural technologies, however, no Brazilian-owned players emerged to produce agricultural inputs. On the contrary, there was an intense process of takeovers of leading Brazilian companies by multinationals, especially in seeds, where public and private suppliers had once led the market (Wilkinson and Castelli, 2000).

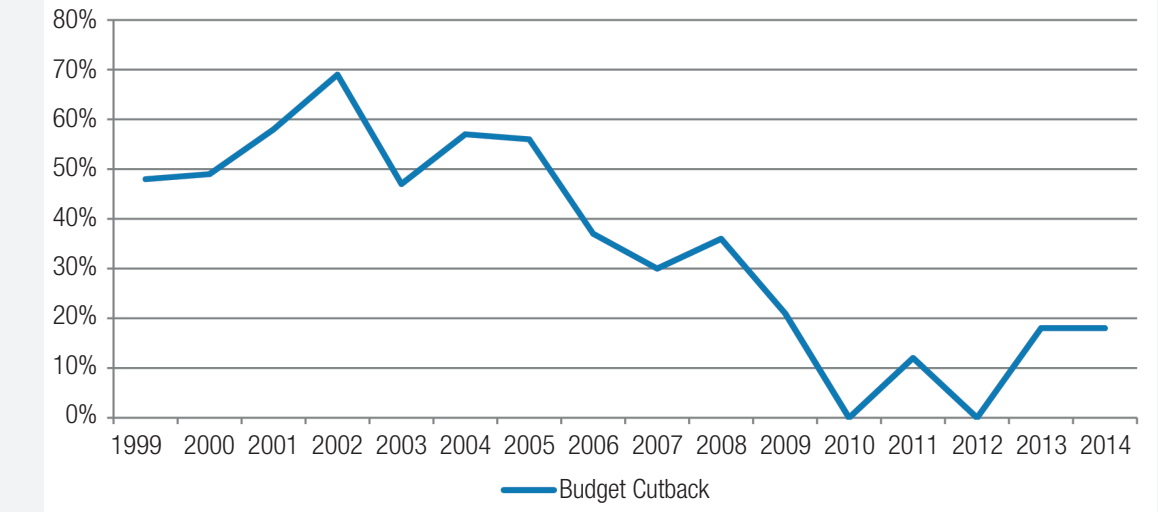
Industry's poor performance also has to do with an ongoing political and institutional lock-in to the past two government's policy priorities. Despite their anti-neoliberal rhetoric, their macroeconomic policies are on a continuum with previous economic stabilization policies, based on high interest

rates. With the high cost of servicing the public debt, the state has to maintain one of the highest tax burdens in the world. This combination of high taxes with high interest rates is incompatible with innovation incentive policies, whose potential gains in competitiveness become irrelevant and incompatible, from a risk/benefit standpoint.

Another aspect relatively neglected by one government after another has been elementary schooling, whose deficiencies have a direct impact on Brazilian industry's low productivity and competitiveness. Although school drop-out rates fell from 35% to 22% between 2003-2012, indicators on the quality of teaching and learning are still among the worst on a list of 65 countries. Brazil's performance ranking in mathematics in 2012 ranged between 57-60; in reading capacity, between 54-56; and in science, between 57-60 (OECD, 2014).

This ongoing dependency on macroeconomic stabilization goals has perpetuated the government's habit of cutbacks for Sectoral Funds, as it prioritizes spending austerity over any chance for long-term industrial policy. This is clear in two reports by the TCU appraising the FNDTC's financial and budget performance. The first report, dated August 2012, listed federal cutbacks on authorized budget items in the Sectoral Funds. In all fiscal years except for 2010, from 12% to 69% of authorized funds were withheld (graph 3).

GRAPH 3 PERCENTAGES OF THE FNDCT BUDGET CUT BACK AND BUDGET IMPLEMENTATION BY THE FEDERAL GOVERNMENT (1999-2014)



Source: Bastos (2003); Tavares (2005); TCU (2012); Finep (2014; 2015); Siafi (2015).

All these budgetary restrictions to the recovery of investments in S&T, through the Sectoral Funds, had fallen short of what was expected. Graph 1 indicates that in the period 1999-2014 the evolution of FNDCT's expenses were very instable and had a strong retraction in the last year. Finep's resources

had, however, a seven times increase in its growth in the last ten years. This increase is mainly related to the transfer of a part of Sectoral Funds, which has contributed to up to 50% of Finep's revenue. Between 2009 and 2015 the federal government implemented the Investment Sustaining Program (PSI) through subsidized financing for the acquisition of capital goods and for investments in innovation and exports. The transfer of federal funds, through BNDES, represented then the main source of Finep's revenue (Finep, 2011; MCTI, 2015). The PSI however, had a budgetary cut of 60% in 2015 and, from 2016 on Finep will no longer count on this source of revenue (Agência Brasil, 2015). This indicates a probable rupture in the continuity of S&T investments expansion of this funding agency.

In another audit conducted in 2012 (TCU, 2013), officials examined a number of administrative aspects regarding compliance with the FNDCT's own management norms, as set forth in Law 11,540/2007, which regulates its operations. That audit highlighted a number of observations:

- The agendas and minutes of the FNDCT Board of Directors' meetings make no reference to planning, discussion or definition of specific policies and guidelines.
- One possible reason why it is so difficult for the FNDCT Board of Directors to draw up policies and guidelines is the Fund's complex governance system, with six different decision-making bodies.
- While the legislation provides that the Board should meet four times during the fiscal year, in practice those meetings take place once a year.
- Another factor that helps explain the lack of FNDCT policies and guidelines is the leeway that the absence of such documents provides for the use of the Fund's resources. Accordingly, the FNDCT is not just another specific fund helping to finance Brazil's science, technology and innovation; it also covers budget shortages in other related bodies and programs.
- This leeway, in the absence of policies and guidelines, creates a convenient situation, i.e. greater flexibility for decisions the use of the Fund's resources.

Such managerial practices that deny any institutional basis for established rules reflect on what Suzigan and Furtado (2006) consider essential for an actual industrial policy, namely, political command and coordination. Command demands the presence of unchallenged political leadership, capable of standing up to antagonisms and conflicts of interest inherent to democratic institutions. The average time in office of Brazil's federal cabinet Ministers evidences the shaky leadership they are able to establish and hold on to. Since Brazil redemocratized in 1985, the Ministers of Science and Technology (graph 4) and of Industry and Commerce (graph 5), responsible respectively for S&T and industrial policy making, have spent an average of 1.5 years in office. They rarely spent even half of a President's four-year term, and most lasted less than 12 months. This illustrates the extreme volatility of public-policy making and coordination in these areas of government. The exceptions to the rule for S&T Ministers (José Israel Vargas and Ronaldo Sardemberg) took place during the terms of Presidents Itamar Franco and Fernando Henrique Cardoso in the 1990s. That was precisely when the Sectoral Funds were set up. Those Ministers' longevity assured the necessary stability in the political and policy streams, which provided legitimacy and the time needed to negotiate the passage of some 20 bills into law in Congress, to create each of the Funds. Conversely, during President Cardoso's two four-year terms in office, there were eight Ministers of Industry and Commerce, in contrast with the Minister of Finance (Pedro Malan), who spent the whole eight years in the same post (graph 6). This

reflects the Cardoso government's priority on macroeconomic stability, over and above industrial development.

When those policies came back into vogue during President Lula's government, we observe a longer time in office for the Ministers of Industry and Commerce (graph 5), an average of four years during his two terms of office. Under President Dilma Roussef, the Ministers' average tenure in this post dropped to two years, and that of S&T Ministers to one year. It is also significant that the Ministers of S&T during President Lula's two terms were all from a political party (the Brazilian Socialist Party - PSB) allied with the ruling Workers' Party (PT). Of the five Ministers of S&T since President Dilma took office in 2011, the last two have also come from allied parties. This reflects a policy of building political alliances in which this Ministry is not a priority on the government's policy agenda, as opposed to the Ministries of Finance, Education and Health. As part of the federal government's core political agenda, these latter Ministries have almost always been headed by members of the President's own political party.

This irregularity in ministerial terms of office goes far to explain recurrent discontinuities in industrial and S&T policies. It means long-term political agendas are rarely set, while it also holds back the formation of skills needed to balance all the different interests at stake. There are 17 members of the FNDCT's Board of Directors, three of them from industry, six from different federal ministries, three from development agencies, three from the scientific community, one representative of workers and one from Embrapa (Law 11,540/2007). The boards of each Sectoral Fund have a similar makeup, as provided by the laws that stipulate their respective governance structures. That governance is also hobbled, however, by a high turnover rate among board members.

Brazil's low priority for investments in R&D also shows up in the percentage of GDP spent on this item, compared to other countries. Graph 7 compares this indicator in Brazil with more advanced economies. Since 2000, when Brazil began publishing this figure, national spending on R&D has been practically constant, at 1% of the GDP, while industrialized countries like the US, Japan and Germany spend up to three times as much, percentage wise. South Korea stood out from all the rest with the highest growth for the period, from 2.3% to 4% of the GDP, a rate that in relative terms actually quadruples Brazil's investments.

Today, with the economy in recession — GDP expected to fall 3.6%, and yearly inflation at 10% — public spending on S&T is dropping, with FNDCT cutbacks in 2015 estimated at 75% (Banco Central do Brasil 2015; Linhares 2015). The major fiscal incentive for innovation, the "Good Law," was suspended for FY 2016 through a presidential Provisional Measure (MP 694/2015). The impacts of these steps go beyond the disruption of public and private investments, as they also foster growing legal uncertainty *vis à vis* incentives and other tools that should be attracting capital into R&D.

Another dimension still neglected by Brazil's industrial and S&T policies is the environment. Although the concern is present in official rhetoric and documents, in practice, science and technology investments have not been matched by financial incentives to assess and control the adverse effects of dominant and/or emerging technologies. This is symptomatic of a broader trend, for example the regression in Brazil's environmental legislation over the past decade, especially the new 2012 Forest Code and amendments to the law that regulates conservation units (Leuzinger and Varela, 2014). Greater permissiveness for farming in buffer zones around conservation units, along with the discharge for farmers who have illegally cleared huge expanses of forest, are factors that have a strong negative impact on biodiversity, one of Brazil's main sources of natural resources, whose sustainable

use might even give the country a competitive advantage. Brazil also stands out as the world's second largest consumer and largest importer of pesticides, including active ingredients that are banned or being phased out in several other countries. This is another example of how environmental risks are not being handled in a manner that might provide innovative alternatives to prevailing farming practices based on the intensive use of poisons (Pelaez et al., 2015).

In these cases, the policy coordination and the demand articulation systemic failures are notorious. A strategy to coordinate a blend of public policies would be an innovative institutional possibility, including social regulation (care for human health and the environment) as a fundamental vector for industrial and S&T policy making. Another telling fact is that the Ministries of Health and the Environment have no seats on the FNDCT Board of Directors, despite the intense science and technology aspects of their respective responsibilities.

After two decades of liberal macroeconomic policies, the resumption of S&T public investments by the federal government, in the 2000s, rescued the significance of industrial policies from the policy stream. The ideas that supported the relevance of S&T investments in this last period were renewed by taking into account the systemic approach of innovation as a backbone of industrial policies. This contributed to giving continuity to the policy stream that was onset from the Sectoral Funds creation, by the end of the 1990s. Both President Lula's terms also provided a relative stability in the political stream, concerning the Ministers of S&T, and mainly the Ministers of Industry and Trade who are in charge of the elaboration of industrial policies. However, this political stability has lost momentum since Pres. Dilma's first term, initiated in 2011. The intensification of turnover in the Ministries of S&T and Industry and Trade, and in 2015 in the Ministry of Finance, is associated with a growing deterioration of the macroeconomic conjuncture. There has been a generalized loss of credibility of the federal government concerning its capacity to create and implement a policy agenda able to stimulate public and private S&T investments. The increasing budgetary cuts imposed by the federal government in S&T investments have weakened the institutional improvements attained since the creation of the Sectoral Funds. In such a scenario the S&T policy agenda has been systematically emptied or discontinued as the federal government prioritizes the emergency issues related to the reduction of the fiscal deficit.

CHART 1 MAJOR S&T SUPPORT INSTITUTIONS IN BRAZIL

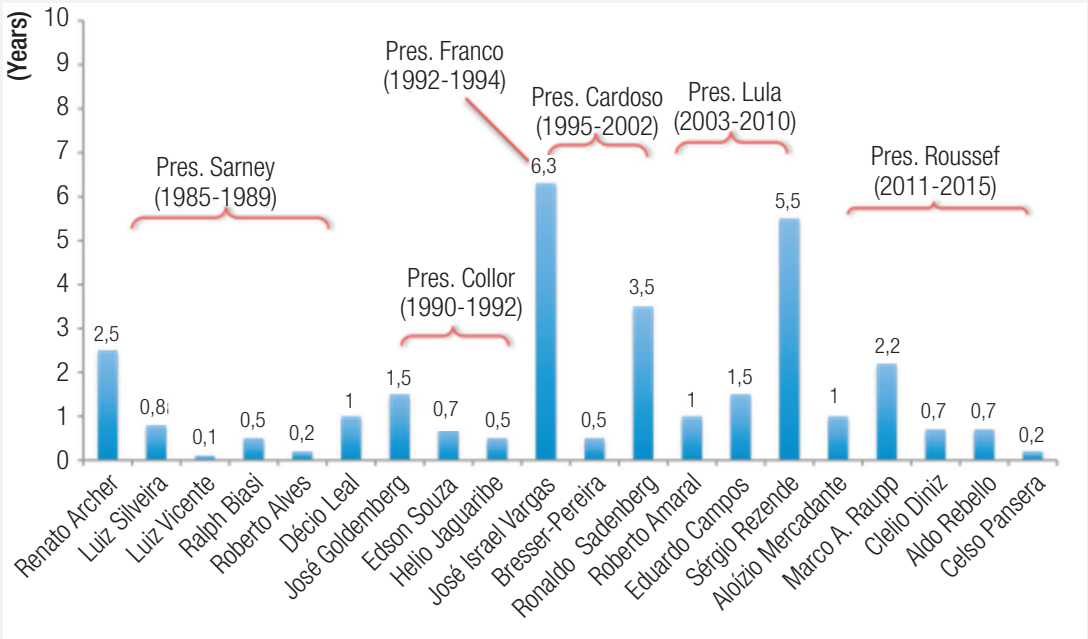
Period	Institution
1950s	• Aeronautical Technology Institute (ITA) • National Research Institute on the Amazon (INPA) • National Pure and Applied Mathematics Institute (IMPA) • National Science and Technology Development Council (CNPq) • Coordination for the improvement of Higher Education Personnel (CAPES) • National Economic and Social Development Bank (BNDES)
1960s	• National Institute of Metrology, Standardization and Industrial Quality (Inmetro) • Funding Authority for Studies and Projects (Finep) • Petrobrás Research and Development Center (CENPES) • National Science and Technology Development Fund (FNDCT)

Continue

Period	Institution
1970s	• Electric Power Research Center (CEPEL) • National Industrial Property Institute (INPI) • National Space Research Institute (INPE) • Brazilian Small and Medium Business Support Service (SEBRAE) • Brazilian Agricultural Research Corporation (Embrapa) • Telecommunications Research and Development Center (CPqD)
1980s	• National Scientific Computing Laboratory (LNCC) • Information Technology Center (CTI) • Mineral Technology Center (CETEM) • National Astrophysics Laboratory (LNA)
1990s	• National Synchrotron Light Laboratory (LNLS)
2000s	• Brazilian Biosciences National Laboratory (LNBio)
2010s	• Brazilian Industrial Research and Innovation Corporation (Embrapi) • National Bioethanol Science and Technology Laboratory (CTBE) • Brazilian Nanotechnology National Laboratory (LNNano)

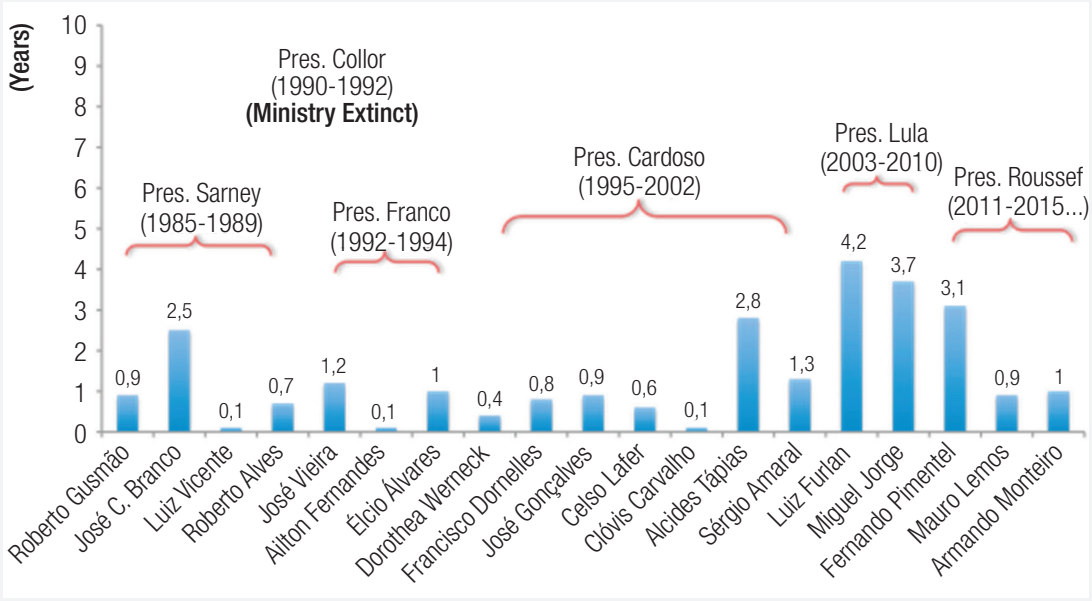
Source: Elaborated by the authors.

GRAPH 4 TERMS OF OFFICE OF S&T MINISTERS AND SECRETAIRES, BRAZIL (1985-2015)



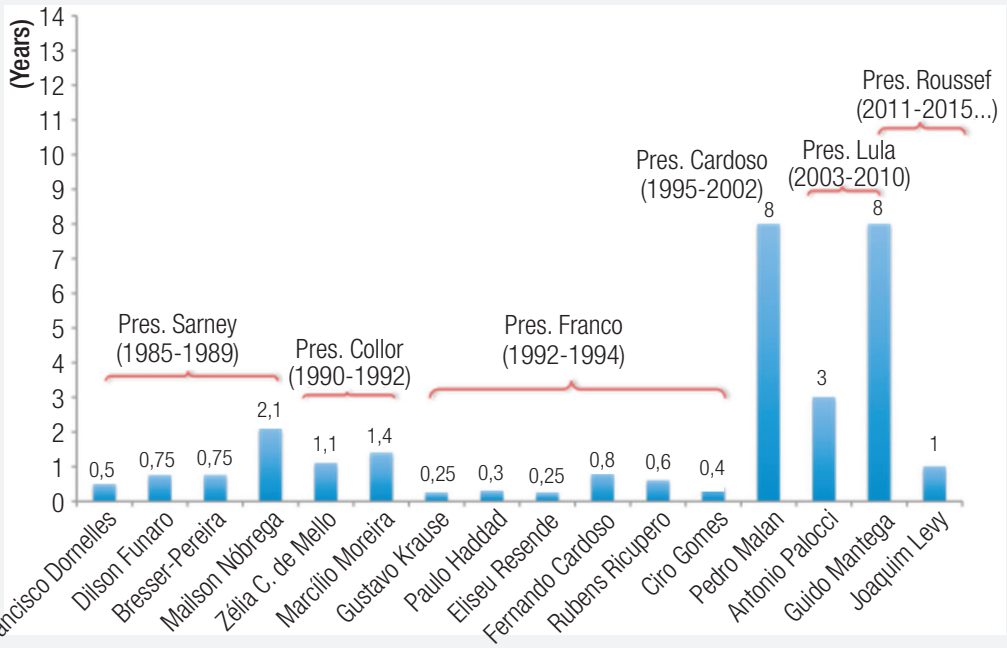
Source: Wikipedia (2015a).

GRAPH 5 TERMS OF OFFICE OF MINISTERS OF INDUSTRY AND TRADE, BRAZIL (1985-2015)



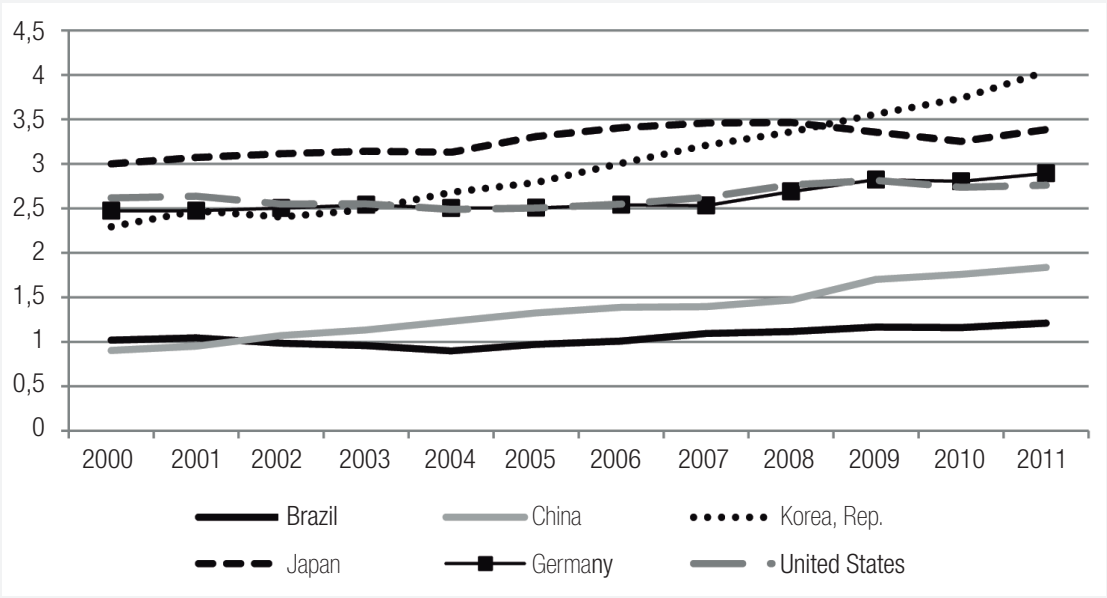
Source: Brasil (2015).

GRAPH 6 TERMS OF OFFICE OF MINISTERS OF FINANCE, BRAZIL (1985-2015)



Source: Wikipedia (2015b).

GRAPH 7 R&D SPENDING IN SELECTED COUNTRIES (% OF GDP)



Source: World Bank (2015).

6. FINAL CONSIDERATIONS

Over the past 60 years Brazil has taken its place among the world's ten largest economies, based on industrial and S&T policies first launched in the 1950s. Although the country broke out of a period of stagnant investments and significantly boosted its R&D spending, in absolute terms, over the past decade, the results of such efforts still fall short of the potential of a country with such abundant natural and human resources. Unable to increase the share of its GDP earmarked for R&D, the makeup of Brazil's exports since 2000 reflects declining investments in high-tech sectors. The loss of international competitiveness in frontier science and technology fields is explained by the irregular and deficient profile of R&D investments over the past 40 years. That deficiency also grows out of the country's fragile institutional capacity to implement incentive policies for innovation. Enhancing its institutions' capacity to coordinate and sustain public policies is thus a major challenge, as a systemic disorder to be overcome.

The discontinuity Brazil's S&T policies arises both from its failure to build along-term state Project and from a systematic disrespect for laws that govern public spending. This institutional lock-in breeds a state of exception, in which practices outside the rule of law become the norm, impeding the adoption of counter-cyclical policies during economic downturns.

The volatility or instability of public funding to sustain long-term public policies actually reveals the volatility of democratic institutions themselves. The state, when taken hostage by a

government's short-term political contingencies, is unable to act upon anything but immediate problems. This leads to all order of systemic failures among which, the incapacity of coordination of macroeconomic stabilization policies with S&T, environmental and social inclusion policies, stands out.

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Victor Pelaez
PhD in Economics and Associate Professor in the Public Policy Graduate Program at the Universidade Federal do Paraná. E-mail: victor@ufpr.br.

Noela Invernizzi
PhD in Science and Technology Policy and Associate Professor in the Public Policy Graduate Program at the Universidade Federal do Paraná. E-mail: noela.invernizzi@gmail.com.

Marcos Paulo Fuck
PhD in Science and Technology Policy and Associate Professor in the Public Policy Graduate Program at the Universidade Federal do Paraná. E-mail: marcospaulofk@gmail.com.

Carolina Bagatolli
PhD in Science and Technology Policy and Associate Professor in the Public Policy Graduate Program at the Universidade Federal do Paraná. E-mail: carolina.bagattolli@gmail.com.

Moacir Rodrigues de Oliveira
MSc in Public Policy at the Universidade Federal do Paraná and Head of General Comptrollership at Parana State. E-mail: moacir.oliveira@cgu.gov.br.