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State-led Innovation: SOEs, Institutional Fragmentation, and Policy Making in Brazil

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Abstract. This paper provides a brief institutional overview of the fragmented, state-led ecosystem for innovation in Brazil highlighting the central roles of ministries, agencies, and especially SOEs as well as less consistent participation of universities, MNCs, and private domestic firms. This ecosystem is embedded in Brazil's particular politics – coalitional presidentialism – which creates high turnover in core positions in government and lately opened up some parts of the state to corruption. Vignettes of innovation successes in areas like airplane manufacture and soybeans illustrate how various agencies and actors interacted in the past.

I. Introduction[1]

Over the past half century, the record of innovation in Brazil has been mixed Brazil has scored some remarkable successes from deep-sea oil exploration, to switching the automobile fleet to flex fuel engines, to adapting soy production to Brazil's tropical and semi-arid conditions, to exporting airplanes. And, Brazil leads the region with more than double the regional average spent on R&D, accounting for close to two thirds of all R&D in Latin America (see (Schneider, 2013), Table 1). However, on the minus side, levels of R&D are still low overall (around half of OECD levels), and especially low in private firms, as are levels of patenting (Brito and Mello, 2006).[2] Understanding this unevenness requires a close understanding of the institutions and politics in Brazil's complex, fragmented innovation ecosystem.

Table 1 – Research and development as share of GDP in East Asia and Latin America, 2000-2010

Country/region	*2000*	*2010*
East Asia*	**1.1**	**1.7**
China	0.9	1.8
Indonesia	0.1	0.1
Korea	2.3	3.7
Malaysia	0.5	1.1
Singapore	1.9	2.1
Taiwan	2.0	2.9
Thailand	0.3	Na
Latin America*	**0.4**	**0.5**
Argentina	0.4	0.6
Brazil	***1.0***	***1.2***
Chile	na	0.4
Colombia	0.1	0.2
Costa Rica	0.4	0.5
Mexico	0.4	0.5

Source: (Stallings 2016, 7) with data from World Bank, World Development Indicators. *unweighted averages.

1 We are grateful to Renato Lima for research assistance and to Fernanda de Negri, Mark Dutz, and participants at an IPC seminar for comments on earlier versions.

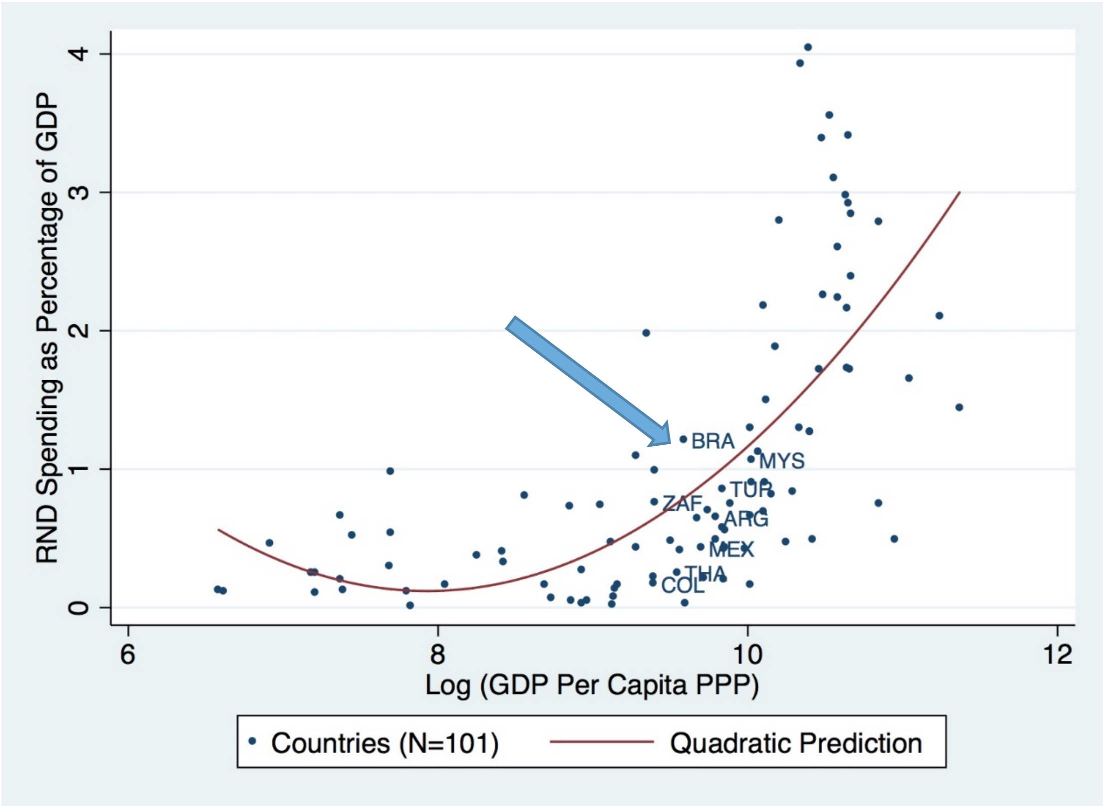
2 "between 1997-2012 Brazil's participation in the total number of patents granted to residents, after having reached a nadir of 0.09% of the world total in 2004, has stabilized around 0.14%" (Frischtak and Davies, 2015, 1).

Innovation in Brazil has long been state driven. Some public institution or policy was behind all of the success cases listed above. More than half of R&D in Brazil is public (and much of private R&D is subsidized by government (Brito)); in contrast in most developed countries business accounts for 2/3 or more of R&D. So, the main focus of this paper is the state, its policies, agencies, and especially SOEs.

Brazil has a long history of sustained industrial policy beginning in the 1930s. By the late 20th century, industrial policy focused increasingly on technology and innovation, and by the 2010s, nearly all industrial policy was innovation policy and vice versa (see (Taylor, 2016)).[3] Brazil stands out in Latin America as the country that: spends the most on industrial and innovation policy, has the largest public bureaucracy devoted to innovation (including in SOEs), and has by far the highest total spending on R&D. Brazil also outspends most other large middle income countries (Figure 1). Figure 1 also shows clearly the challenges ahead (the upwardly sloping curve); high income countries spend much more on R&D.

[3] By industrial policy, we understand any policy that favors one sector or activity over others. Innovation policy promotes everything from the discovery of new products and processes to basic improvements in technology and productivity. Some industrial policy in Brazil has a more quantitative goal, as in expanding production, but most policies seek at least indirectly to increase productivity.

Figure 1. R&D and GDP per capita



Source: From (Doner and Schneider 2016). For all income levels with available data, excluding high income petro states (Kuwait, Saudi Arabia, Oman, and Trinidad and Tobago) and financial havens (Bermuda and Macau).

The Brazilian government uses a full range of policy instruments to promote innovation, including direct subsidies, tax exemptions, government procurement, mandated spending and contributions by firms, local content requirements, trade protection, and research grants. Total spending on industrial policies increased from 3 percent of GDP in 2006 to 4.5 percent of GDP in 2015. The bulk of this spending comes through tax expenditures (more than half of total spending) and subsidized credit; direct expenditure average only .5 percent of GDP (Worldbank, 2017). The loans of the national development bank, BNDES, alone rose to four percent of GDP (which entailed a public subsidy on the order of one percent of GDP). To put these numbers in context, the popular and effective anti-poverty program, *Bolsa Familia*, reaches 50 million people and costs only .5 percent of GDP.

The government also created over the past six decades a full panoply of institutions and organizations to support innovation including ministries, state owned enterprises (SOEs), development banks, regulatory agencies, university incubators, social organizations (publicly funded but privately operated), business-government councils, venture capital funds, research institutes, and other public agencies. A core goal of this paper is to map out this institutional diversity in an effort to establish which institutions matter most and which have been most effective.

Beginning in the 1950s, the government began creating a range of agencies, institutes, state owned enterprises (SOEs), and programs designed to promote innovation. Some of the earlier entities in included Capes, CTA, BNDES, and Petrobras. Thereafter institutional change was continuous, incremental, and mostly by accretion as new more specialized entities were added to the institutional ecosystem such as Finep (*Financiadora de Estudos e Projetos*) in the 1960s, Embrapa (*Empresa Brasileira de Pesquisa Agropecuária*) in the 1970s, sectoral funds of 1990s, up to Embrapii (*Empresa Brasileira de Pesquisa e Inovação*) in 2010s (see appendix).

Decades of accretion added up over the 20th century to sustained institutional fragmentation. Most attempts at central coordination have been short lived and ineffective in part because many entities were created with substantial formal autonomy. In many cases, these designs to promote autonomy were intended to shield agencies from clientelist politicians (Schneider, 1991). Autonomy in many cases did offer significant insulation, especially in smaller entities, or "pockets of efficiency" (Evans, 1995). However, after democratization in 1985, innovation agencies and policies were subject to the pressures of maintaining government coalitions in Brazil's evolving system of coalitional presidentialism which in turn reinforces fragmentation and impedes policy coordination. Many analysts criticize this fragmentation and urge greater coordination (Zuniga et al., 2016).[4] However, fragmentation and decentralization may at times also be one of the strengths of Brazil's innovation system (as in the United States).

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[4] In Weyland's unflattering characterization (Weyland, 1998, 53), "starting out as a powerful Leviathan in the 1940s..., Brazil's developmental state ended up as an obese, uncoordinated Gulliver, unable to turn its weight into strength and tied down by innumerable bonds to narrow interest groups and clientelist networks." (Brito and Mello, 2006, 26) also criticize problems of "excessive fragmentation," with corresponding need "to foster coordination..."

Beyond statism, the other main overall characteristic of Brazil's innovation system is that is it relatively, though unevenly, closed to the global economy. This closure is especially notable in trade and continuing protection against imports, but is also true of the scientific and university system (the policy of "Science without Borders" was intended to remedy this but it only lasted a few years, 2011-15). However, Brazil is, compared to many Asian countries, quite open to foreign investment, and MNCs account for half of private R&D (Do Couto e Silva Neto et al., 2013, 2).

Section II provides a basic institutional and policy map of Brazil's innovation ecosystem and documents the expansion over the past half century of the main actors in this policy realm. Section III discusses the difficulties public innovation agencies have had in building closer collaboration with universities and with business. Section IV situates the public innovation constellation in the broader political context, focusing especially on the appointive bureaucracy and coalitional presidentialism. Section V adds dynamics and specificity to the institutional ecosystem by analyzing particular cases of successful innovation including flex fuel, soy, and aerospace. Section VI concludes with a brief discussion of the implications for Embrapii and for Senai's Innovation Institutes (*Institutos SENAI de Inovação*, ISIs).

II. Institutional and Policy Evolution[5]

As in the 20th century, the recent conduct of innovation and industrial policy in Brazil was fragmented across many ministries, SOEs, and agencies. No centralized agency comparable to the Economic Planning Board in Korea, or later the Korean Ministry for the Knowledge Economy, or the Commissariat du Plan in France existed to coordinate dispersed policies and their implementing agencies. Thus, mapping out public support for innovation in Brazil, requires covering a wide range of dispersed ministries, agencies, departments, SOEs, and foundations. In this fragmentation and lack of centralized control, Brazil resembles the United States (Block, 2008; M Mazzucato, 2015). The following, brief overview considers several dimensions of the main organizations involved in innovation: functions, type of organization, and resources. The

[5] For more in depth reviews, see Zuniga (2016).

main functions are: 1) planning, 2) coordinating, 3) funding, and 4) actually doing R&D (see Table 2).[6] Evaluation could be a fifth main function, but very little evaluation has been conducted (with the exception of the public research institute, IPEA (*Instituto de Pesquisa Econômica Aplicada*).

Table 2. Innovation Institutions by Type of Function

Planning	Coordinating	Funding	Doing
MCTI(C)	MEI	BNDES	Embrapa
Regulatory agencies	Interministerial councils	Finep	CNPEM, IPT (and other public research institutes)
MEC	ABDI	Sectoral funds (FNDTC)	Fiocruz
Anvisa		Fapesp	Cenpes/Petrobras
MDIC		Embrapii	MNCs (ICT & auto)
		Tax exemptions (ICT)	Embraer
		Lei do Bem	Senai ISIs

Ministries. At this level, innovation policy and implementation was scattered across several ministries, from the Ministry of the Airforce, to Energy, to Planning Although the name would suggest a dominant role, the Ministry of Science, Technology, Innovation, and Communications (MCTIC) was in fact fairly small in terms of personnel and budget, and its minister has often been a politician without much background in innovation (discussed further in Section IV).[7] Table 3 gives the budgets of key innovation agencies. For purposes of comparison, we include lending by BNDES to show how its resources over shadow all others. Table 3 also includes the largest state-level institution, Fapesp.

6 The table is illustrative rather than exhaustive. For full names, see the Glossary.

7 The Temer government merged the former ministry of communications into MCTI in 2016.

Table 3. Innovation Agency Budgets in Brazil, 2014

Institution	Amount (R$ billions)	Percentage (excludes BNDES)
BNDES	135.9	--
MCTIC	7.2	31
Finep	1.2	5
Fiocruz	4.3	19
Embrapa	2.9	12
Cenpes - Petrobras	2.5	11
CNPq	2.4	10
MDIC	1.2	5
Fapesp	1.2	5
Embrapii	.11	0.5
DCTA	.07	0.3

Note: See appendix on sources. The amount for BNDES is total loans disbursed; for other agencies it is budgetary spending.

Agencies. Although many are connected to a ministry, agencies usually have some autonomy from the ministerial hierarchy and are devoted to a specific industry or sector.[8] Regulatory agencies in areas like oil (ANP, *Agência Nacional do Petróleo, Gás Natural e Biocombustíveis*), electricity (Aneel, *Agência Nacional de Energia Elétrica*), health (Anvisa, *Agência Nacional de Vigilância*), and telecommunications (Anatel, *Agência Nacional de Telecomunicações*) have independent authority and usually some political independence through fixed mandates for directors. In Brazil, regulatory agencies often have developmental functions and participate in committees with oversight on sectoral funds devoted to innovation (see later discussion of Finep). In a more prominent example, the ANP formally oversees the local content policy that Petrobras implements with a huge impact on industrial and technology policy. Anvisa promoted innovation in pharmaceuticals by using its purchasing power to help Brazilian producers into generic drugs (see section V).

[8] Created in the 2000s, ABDI, the Brazilian Agency for Industrial Development, would seem, by its name, to be an important institutional component of the innovation system. ABDI however has little staff or resources or clear mandate as so is overshadowed by other institutional entities.

State-owned enterprises. In Brazil, state-owned enterprises (SOEs) operate under more flexible procurement, labor, and other rules than other public agencies, so for decades policy makers have favored them in industrial policy. Even though Brazil was a world leader in privatization in the 1990s in terms of the value of state assets sold, the government held on to some of the largest SOEs like Petrobras, BNDES, and smaller strategic SOEs like Embrapa and Finep, and kept golden shares in Embraer (airplanes) and Vale (mining) (which kept them from moving abroad or from being sold to a foreign competitor).

Within this context, SOEs occupy a pivotal practical, and theoretically uncertain, position. In one perspective, they are merely flexible agents that facilitate and execute a range of state interventions and industrial policies decided elsewhere in the state. However, these SOE implementors or agents have significant power resources, or grow overtime to have them, especially the larger ones, so that they are also participants in formulating overall policies, and independent actors in designing their own policies, as well as eventually implementers of policies decided elsewhere. This is especially the case in Brazil where SOEs have been larger and more proactive in industrial policy than SOEs were, for example, in Japan and Korea. In the comparative scheme of things, Brazil's developmental state was, and is, SOE heavy (Schneider, 2015b).

Within the decentralized constellation of agencies involved in innovation policy, BNDES and Petrobras emerged as primi inter pares. Within total spending on industrial policy, the primary source of subsidized credit and minority shareholding was the BNDES, and the largest source of direct government procurement was Petrobras. For example, in 2015, BNDES loans accounted for 21 percent of all outstanding loans to firms and individuals, in 2010 BNDES loans rose to 4.3 percent of GDP, and by 2015 all BNDES assets (loans, shares, and other investments) totaled 16 percent of GDP (Armijo, 2017, 3).[9] As such the BNDES and Petrobras engage in industrial policy in distinct ways, the BNDES through credit and share ownership and Petrobras largely through its own R&D and its administration of policies of requiring higher levels of

9 BNDES has smaller targeted programs ("over 40 programs, products and funds to support innovation" (Frischtak and Davies 2015, 29)) such as Inova Petro and alternative energy. However, many of its larger, traditional loan portfolio involve innovation as in the large program (Finame) tat finances new equipment purchases. Even the national champion policy of promoting international acquisitions by Brazilian firms had R&D capacity as one of its targets.

domestic content in its massive supply chain. Petrobras holds the most patents of all Brazilian firms (Brito and Mello, 2006, 12). Beyond their practical importance in terms of the large share or resources they mobilized, BNDES and Petrobras are also revealing because their technical staffs were among the most professionalized and independent within the state. That is, they were two of the long standing and historically evolved pockets of efficiency (recent corruption scandals are considered later).

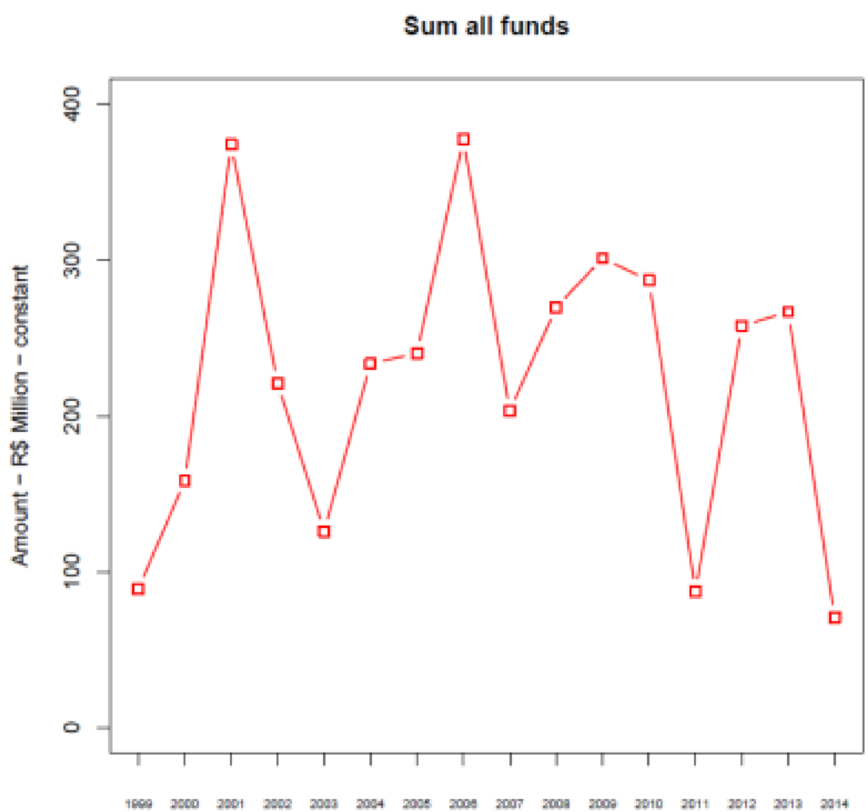
In the 2000s, BNDES lending portfolio grew dramatically, doubling from two percent of GDP in 2000 to over four percent in 2010 and came to outpace lending by the World Bank and IDB (Almeida, 2011a, 9). The BNDES is still, as it has been for decades, the principal source of long-term and export credit for large private firms. As a percent of all financing for industry and infrastructure (including retained earnings, international loans, bonds, and equity), BNDES credit ranged from 20 to 30 percent over the 2000s (though spiked in 2009 to 50 percent) (Ferraz, 2011, 25). Moreover, the BNDES (through its shareholding subsidiary BNDESpar) became the largest institutional investor in Brazil.

Beyond the two behemoths BNDES and Petrobras, a fuller analysis of SOEs and innovation in Brazil would also include those in electricity and health, and especially smaller strategic SOEs in research and innovation, namely Finep (funding), Embrapa (agricultural research), and Fiocruz (health research). Embrapa in particular is considered one of the clearest cases of successful promotion of innovation and upgrading in soy and other agricultural products (Furquim et al., 2016; OECD, 2015). Overall by 2014, the federal government had 135 SOEs with over 500,000 employees (Lima, 2017a).

Another strategic SOE was Finep created in the 1960s. Through the late 1990s, Finep managed its own resources as well as those of FNDCT (*Fundo Nacional de Desenvolvimento Científico e Tecnológico*) (Melo, 2009). After 1998, the creation of additional sectoral funds (FNDCT, from 1 fund in 1999 to 13 in 2002 (end of Cardoso government) to 15 by 2005) injected major new resources into Finep (nearly R$600 million by 2004 and a cumulative total of around $1 billion by 2005) mostly for cooperative projects between business and universities or research institutes (Brito and Mello, 2006, 20; J. de Negri, Lemos, and De Negri, 2006, 4) (see

Figure 2).[10] However, of the 15 different funds, three disbursed nearly three quarters of all funds from 1999-2014 (CT Infra with 46 percent, CT-Petro with 17 percent, and CT-Verde-Amarelo, 8 percent) (authors' elaboration using data from MCTI – Aquarius platform). Although Finep still managed these funds, the 1998 legislation shifted strategic decision making from Finep to management committees for each fund that included representatives from Finep but also relevant ministries, CNPq,

Figure 2. Total contracts awarded for all 15? Sectoral funds, 1999-2014



Note: The values are for all projects contracted. Others assess the size of funds by the amount committed (*empenhados*) but these funds were often not spent (*contingenciados*).

Araujo et al. offer a a positive assessment of the impact of the sectoral funds (FNDCT) administered by Finep on firm R&D (Araújo et al., 2012). The findings in this study merit

[10] Some of these sectoral funds were conceived as substitutes for R&D previously conducted by the SOEs in sectors like electricity and telecoms. When these SOEs were privatized, the funds provided a mechanism to continue to promote R&D in these sectors as well as build bridges to universities.

emphasis. Very few of Brazil's myriad innovation policies ever get evaluated, and existing research on their impact usually suffers from the generic problem in industrial and innovation policy of not being able to establish the counterfactual, namely what would have happened in the absence of government policy (Pack and Saggi, 2006). Araujo et al 2012 solve this problem with Propensity Score Matching to compare firms who received FNDCT subsidies with comparable firms that did not to show the positive impact on receiving firms.

Public universities. Research universities are pivotal players in any innovation system in three crucial roles: basic research, collaborative R&D with business (discussed later), and producing the scientists, engineers, and other personnel to staff the innovation system.[11] In Brazil, governments over decades, especially after the 1960s invested heavily in research capacity (J. de Negri, Lemos, and De Negri, 2006; Suzigan, 2011; Suzigan and Albuquerque, 2011)."The lion's share of government support (almost two-thirds of government spending on R&D) is directed to public universities and research institutions, with a small share devoted to businesses" (Brito and Mello, 2006, 6). And, in recent decades, output (scientific publications) has been fast increasing, especially in areas like tropical medicine, agriculture, biochemistry, and genetics (Frischtak and Davies, 2015, 15). Frischtak and Davies conclude that, "Brazilian science is not an impediment to technological innovation" (Frischtak and Davies, 2015, 12), and some universities were pivotal to the success cases in section V. State-level foundations, especially Fapesp in São Paulo, also channel millions of dollars in R&D funding, mostly through universities. In 2003 about a third of all public funding for science and technology was funded by states (Brito and Mello, 2006, 6).

In terms of producing innovation personnel, "Brazil's poor record in educational attainment is among the key obstacles to the generation and diffusion of innovation" (Brito and Mello, 2006, 23).[12] Overall, the proportion of the adult population with tertiary education has stagnated at the 10-15 percent range, compared to 20 percent in Chile and Argentina, and 30-50 percent in rich countries, and the share in science and engineering has been falling to levels well below other developing countries (see Table 4). On bright spot is the high production of PhDs,

[11] Around two thirds of university enrollment is in private universities. However, private universities rarely engage in research.

[12] Scarcity of human capital is a common lament in analyses of innovation in Brazil (Frischtak and Davies, 2015).

though again with slightly lower proportions in science and engineering. Low past enrollments contribute to current shortages: "The stock of engineers graduated per thousand population -- 0.08 in Brazil, against 0.22 in the United States; 0.33 in France and Germany, and 0.8 in South Korea -- illustrates the country's deficit in this area" (Brito and Mello, 2006, 24).

Table 4 – Higher education in science and engineering in East Asia and Latin America, 2000 to 2010

Country/region	*Share in science and engineering of population with first degree (percent)*		*Share in science and engineering of population with PhD (percent)*	
	2000	*2010*	*2000*	*2010*
East Asia*	3x?	39	54	47
China	53	44	58	59
Indonesia	27	na	na	na
Korea	41	36	44.9	36
Malaysia	24.	35	na	49
Singapore	68	45	na	na
Taiwan	37	36	59	63
Thailand	18	na	na	27
Latin America*	23	19	63	57
Argentina	23	17	89	56
Brazil	*21*	*11*	*52*	*44*
Chile	26	18	88	70
Colombia	23	22	Na	61
Costa Rica	Na	19	Na	Na
Mexico	29	27	21	34

Source: Stallings 2016, 6, with data from World Bank, World Development Indicators. *Unweighted averages

Private institutions. Private business is of course crucial to innovation though its R&D spending– averaging close to .5 percent of GDP for most of the 2000s – is less than the public sector and less than business contributes in OECD and East Asian countries (F. De Negr, 2012). In 2012, the government accounted for 28 percent of total R&D, higher education 27 percent, and companies 45 percent (Frischtak and Davies, 2015, 28). However, among companies, MNCs account for half of private R&D and SOEs like Petrobras account for another large share. In Korea and the United States, around 80 percent of scientists work in the private sector, versus 26 percent in Brazil (Brito and Mello, 2006, 12).[13] Despite the small amount spent, a significant share of firms surveyed (Pintec) – increasing over the 2000s towards 40 percent -- say they have invested in innovation activities, though nearly all involve products and processes new to the firm, not new to the sector or country (Cavalcante and De Negri, 2011; Frischtak and Davies, 2015). Moreover, "the acquisition of machinery and equipment, which embody technologies developed elsewhere, is reported as being the main source of innovation by Brazilian firms" (Brito and Mello, 2006, 13). In terms of sectoral distribution, the motor vehicle and transport equipment sectors accounted for 39 percent of total R&D expenditure in manufacturing in 2003, following by chemicals (12 percent) and fuels (11 percent) (Brito and Mello 2006, 13, 15).

Business associations. With one exception, the traditional, corporatist associations for business have had little impact on the innovation. The exception is CNI which both repurposed part of the Senai training system to get directly into joint innovation projects with business (discussed later) as well as created from scratch MEI (*Mobilização Empresarial pela Inovação*, Business Mobilization for Innovation) (analyzed further in Section III). Anpei (*Associação Nacional de Pesquisa e Desenvolvimento das Empresas Inovadoras*, Brazilian Association for Research and Development of Innovative Firms) was founded in 1984. By the 2010s, Anpei had 250 members and put on the largest annual conference on innovation in Brazil (http://anpei.org.br/sobre/). Half of the member firms are large (over 500 employees) and about one quarter are foreign. In addition, about 90 research institutes – both standalone like IPT and university-based – also belong. However, beyond the visibility of the conference and other events, and some lobbying, Anpei does not have much direct impact on R&D or innovation policy.[14]

Four types of sometimes overlapping domestic firms make distinct contributions to innovation and R&D in Brazil: MNCs, business groups, Brazilian MNCs, and venture capital.

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[13] After 2005, the government allowed firms to deduct 50 percent of scientists' salaries. For some, "public universities and government research institutions and agencies, crowd out (public and private) firms, and absorb a disproportionate number of high performance human resources" (Frischtak and Davies 2015, 6) and 73 percent of firms (Pintec) cite "lack of qualified personnel" as a major impediment to investing more in R&D. However, it may be less a matter of crowding out than of lack of demand from the private sector – in other countries private firms find resources to pay more to hire R&D personnel.

[14] Most overview studies of innovation in Brazil barely mention Anpei. See, for example, (Brito and Mello, 2006; Frischtak and Davies, 2015; Mariana Mazzucato and Penna, 2015).

MNCs account for half of private R&D (Do Couto e Silva Neto et al., 2013, 2).[15] MNCs dominate the transportation equipment sector, which, as noted above, accounts for 39 percent of R&D in manufacturing. However, overall, according to the Pintec survey, MNCs do less R&D -- as a percent of turnover -- than Brazilian firms (Brito and Mello, 2006, 14). Thus, the fact that MNCs account for half of R&D owes more to the fact that they are so large rather than that they invest at much higher rates. Second, among large domestic firms, many are diversified business groups, often concentrated in natural resources and non-tradable and service sectors. The largest business groups do virtually no R&D (Schneider, 2013). This poor record notwithstanding, business groups offer in principle advantages in innovation implementation in pushed or induced, because they can pool resources to sustain long term investment in R&D (Nokia is the classic example) (see Section V on Votorantim Novos Negocios).

Fourth, in the 2000s, a number of large Brazilian firms began more aggressive outward investment through foreign acquisitions. BNDES provided lots of financial help premised in part on the hope that foreign acquisitions would allow Brazilian firms access to latest technology and management practices. And, in one study, "Brazilian firms with operations overseas tend to engage more in product innovations at home, to demand more skilled labour and to spend more on labour training than their counterparts that do not have operations abroad" (Brito and Mello, 2006, 14). Lastly, a missing component in Brazil's innovation system is a vibrant venture capital sector with abundant funds to invest in start-ups. By the mid 2000s, "the supply of venture capital and private equity [was] expanding but remains relatively under-developed" (Brito and Mello, 2006, 21). Finep and BNDES promoted venture capital in the 2000s, but without as yet a big impact.[16]

Before closing this institutional overview section, it is worth considering some of the main policies over the past several decades that attempted to mobilize the actors and agencies considered so far for the task of furthering innovation (Table 5). Innovation and industrial

[15] It is important to bear in mind that many of these firms received some kind of government support. According to Pintec 2014: "there was a dramatic increase in government support for R&D. In the beginning of the decade, around 19 percent of innovating firms declared having received some kind of government support to innovate. This proportion grew to more than 34 percent in 2011 and more than 46 percent in 2014."

[16] Private equity, working with medium-sized, established firms has expanded rapidly. However, PE firms tend to improve productivity by promoting scale, consolidation, and financialized management.

policies are too numerous to consider in any detail. The intent of the following tables is to emphasize the large number of policies, their shifting focus over time, and their high overall cost.

Table 5. Summary of main industrial policies in Brazil, 1997-2012

Name	Date	Target sector or activities	Policy instruments
Local content	1997	Oil and gas supply chain, shipyards	Incentives in bidding rounds for purchasing capital goods locally
Prominp	2003	O&G operators and supply chain	Worker training, minimum requirement for local content
PITCE	2004	Software, capital goods, pharmaceuticals, biotechnology, nanotechnology, renewable energy	Tax breaks for capital goods, new loans from BNDES, and support for clusters (APLs).
PDP	2008	20+ sectors, including capital goods, energy, automakers, defense, textiles, and toys. Promotion of investment, exports, and innovation	Tax breaks, subsidized loans, access to venture capital and direct purchases by government. **Annual cost .24percent of GDP**
Greater Brasil Plan	2011	Five structuring guidelines that encompass virtually all sectors, from oil and gas to retail business, toys, and shoes.	Tax reduction (new investments, exports, innovation), government purchases. New and expanded loans from BNDES. **Annual cost .6 percent of GDP**
Inovar Auto	2012	Automakers	Tax reductions for local R&D, engineering, developing suppliers.

Source: Schneider (2015b)

In addition to broader industrial policies, a range of other policies sought to promote innovation more directly (Table 6). The Innovation Law of 2004 promoted private-public cooperation among private firms and universities to do joint research, allowed researchers in public universities to benefit (additional income) from successful innovations in these joint research projects, and set a program for public grants to promote innovation efforts of private enterprises according to the priorities set in the Pitce. The other important legislation change was Good Law of 2005. Before this, firms had to apply for prior approval for an R&D project to the Ministry of Science, Technology, and Innovation, and then wait for the Ministry's approval of fiscal incentives before investing. With the new law, firms could just deduct eligible R&D expenses from their taxes without prior approval. In addition, the government reduced taxes on software firms whose exports accounted for at least 60 percent of total revenue, and started a program to pay between 30-60 percent of the salaries of researchers working in R&D. Total tax spending through the Lei do Bem reached about $1 billion by 2010 (about half of the total for exemptions under the Informatics Law) (Canêdo-Pinheiro, 2013, 15).

Table 6. Summary of Selected Innovation Policies since 1990

Name	Date	Target sector or activities	Main policy instruments	Average annual spending (% of GDP)*
Informatics Law	1991	Information technology (IT)	Tax reductions; preference in government procurement.	.10
Sectoral Funds (FNDCT)	1997	14 funds target specific sectors (including oil and gas, telecoms, IT)	Mostly managed by FINEP, resources are allocated according to projects selected by public bids	.04
Innovation Law (10.973/2004)	2004	Horizontal	Facilitated partnerships between private sector and universities	
Good Law (Lei do Bem)	2005	Horizontal	Tax exemptions for companies that engage in R&D projects	.04

*source for spending estimates, (Canêdo-Pinheiro 2013)

The enduring subsidies created through successive industrial policies certainly helped compensate business for the other difficulties they faced like very high interest rates, overvalued exchange rates, the highest taxes in Latin America, and poor infrastructure (Roriz, 2014).[17] But, was it worth the cost? The total cost is unknown, but some rough estimates have been calculated. By one estimate, PDP policies cost .24 percent of GDP per year (calculated from Ministry of Finance 2011, 16), and Greater Brasil cost .6 percent of GDP (Salto and Pessôa, 2011). Other estimates put total subsidies granted through BNDES lending at around 1 percent of GDP (Castelar, 2007) (Worldbank, 2017). Considering that Bolsa Familia reached 50 million people and had a major effect on reducing poverty -- at a cost of about .5 percent of GDP per year -- greater visible benefits, even in the medium run, were to be expected from such a large expense on industrial policy.

[17] In 2012, after seven years in operation, only 737 firms were able to take advantage of Lei do Bem. Under this law, deductions for R&D can only be made against actual profits and thus most start ups and smaller firms do not qualify (Frischtak and Davies, 2015, 29).

Although only partly related to innovation, a last key area of policy is various barriers to trade and to entry into Brazil of goods, services, and people.[18] Trade defense was a component of Plano Brasil Maior and the number of anti-dumping measures. A less visible form of protection comes through anti-dumping petitions. Anti-dumping really took off in Dilma's first term with one 150 procedures, making Brazil the world leader in such procedures. Among measures in place in 2014, 58 percent were in monopoly sectors and 91 percent were is sectors with three or fewer firms (Tavares, 2015). Brazil also implemented an extra exception list to the Mercosul's Common External Tariff (CET), in which tariff increases were introduced to 100 different tariff lines. The measure resulted in the simple average tariff of these lines increasing from 14 to 22 percent.[19]

The main take-aways from this institutional and policy overview are three. First, policy makers in PT governments were very active in designing new policies, creating new agencies and programs, and generally reviving industrial and innovation policy, though with little overall coordination. Second, these public investments were costly but not matched by private efforts. Third, the results are marginal when known but mostly as yet unknown since little has been invested in evaluation.

III. Tenuous Connections: Innovation Agencies, Universities, and Business

In the 21st century, the gold standard (aka triple helix) for effective innovation ecosystems is close integration and collaboration among government, business, and universities. By this standard, the record in Brazil has been patchy and uneven, with some cases of very effective collaboration (see section V) but overall low levels of integration. Compared to East Asia, few forums exist for business and government to collaborate (with MEI serving as an

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[18] For some, reducing these barriers is the most important policy reform for innovation (Frischtak and Davies, 2015, 32).

[19] Beyond import protections, the country also intensified the use export promotion policies. In 2011 it enacted the *Reintegra* program, through which exporting firms can recover part of indirect taxes levied across its production chain. It also expanded the drawback regime. In this regime, import tariffs and indirect taxes are suspended for imported inputs used in exported products. After 2010, the drawback regime would also benefit the purchase of local products to be used in exports.

exception that proves the rule).[20] Collaboration is more frequent between business and universities, especially in the state of São Paulo, though the overall pattern is subject to debate.

On the relationship between business and government, relations since democratization in the 1980s has been mostly distant and informal. In Lula's first term, the government made several efforts to institutionalize dialogue through the CDES as well as an industry council (CNDE) chaired by MDIC. But, the latter fell into disuse, and CDES was so large (close to 200 members) that it became more of a large sounding board, rather than a deliberative and decision-making council (Doctor, 2007). Business representatives are also included in numerous lower level committees and commissions. For example, sector funds (FNDCT, discussed earlier) have committees with representatives from business and universities that make all disbursement decisions (Brito and Mello, 2006, 20). However, little research is available on how the lower level councils work. Of course, Lava Jato and related investigations revealed how deeply integrated, and implicated, many big businesses were in party and electoral politics through systematic bribery and kickback schemes. However, most of the policy machinery of industrial policy seems to have been little affected (save local content policy in oil and gas) (see Section IV).

BNDES officials have a lot of contact with business and have very detailed knowledge of their sectors and activities. However, this does not automatically translate into real collaboration of the sort envisaged by in Evans' concept of embedded autonomy. For one, the relationship with individual businesses was often arm's length. Firm's seeking credit have to give the BNDES enormous amounts of information, but BNDES officials may not have frequent contact with recipient firms. Moreover, the BNDES had no organized dialogue with business. True, the BNDES does sat on all major business-government councils, but the BNDES did not have a channel or organized discussion for business on BNDES' operations and overall strategy.

MEI was one of the major institutional innovations of the late 2000s. In part due to the absence of other forums for ongoing business-government consultation, the CNI invited CEOs of

[20] Research on the success of East Asia tigers emphasized the very close collaboration between business and government, or "embedded autonomy" in Evans' (1995) term (Amsden, 2001; Campos and Root). For a review of experiences in Latin America, see (Schneider, 2015a).

the largest businesses in Brazil with interests in innovation, both foreign and domestic, and then invited ministers, agency heads, and SOE presidents (especially BNDES, Finep, and the head of Petrobras R&D at Cenpes) involved with innovation. Initially, the quarterly meetings were small with only a few dozen participants but grew by 2016 to include 121 member firms (CNI, 2016).

In has long been a commonplace that business and universities collaborate little and rarely. For example, do Couto y Silva et al. Find that firms “cooperate little with universities and” public research institutes (2013, 289). Brito and Mello find that “co-operation between businesses and universities for joint R&D projects is rare. For Frischtak and Davies, “There is a cultural chasm between research and teaching institutions, on the one hand, and firms driven by the requirements and pressures imposed by markets” (Frischtak and Davies, 2015, 33).[21]

According to Pintec surveys, “only about 11 percent of innovative enterprises in Brazil co-operate with other firms or universities/research institutions, against 17 percent in the European Union” (Brito and Mello, 2006, 17). In another survey of 204 industrial firms, only nine percent said that source of information for innovations in their firms came from universities (another six percent came from public research institutes) (Suzigan, 2011, 4–5). Firms are more likely to go to universities to seek help to solve particular technical problems through consulting, conferences, informal exchanges, and sometimes joint research (Suzigan, 2011, 10–11). However, some recent research has shown that collaboration is happening more often (Brito, de Negri survey). Unicamp has been a pioneer and leader in promoting closer collaboration with business. It created a special agency, Inova, that by the mid 2000s had a staff of around 50, to promote technology licensing, joint R&D with business, and start-ups (Brito and Mello, 2006, 12).

In sum, in line with Brazil’s state-led innovation system, the state side of the triple helix (government and public universities) was fully integrated. What were generally weak, or at best uneven, were the other two sides of the triangle linking business to government and to universities.

[21] By contrast, about 5% of funding for R&D carried out by universities and research institutions comes from the business sector in the OECD area on average (about 7.5% in the United States) (Brito and Mello, 2006, 6). See de Negri and Reynolds (2017) for a full analysis. In terms of interactions between firms and universities or public research institutions, MNCs and domestic firms are quite similar (Do Couto e Silva Neto et al., 2013).

IV. Broader Context: Appointive Bureaucracy and Coalitional Presidentialism

At first glance, Brazilian politics is a welter of parties (30+ at last count) and politicians, sometimes colorful, often corrupt, and always in motion. Two key features structure much of the flow of politics and are especially consequential for innovation policy (and most other policies too). First, nearly all positions in the 4+ top layers of the executive branch including SOEs (essentially all positions with power and policy influence) are subject to direct appointment (and removal) by the president. Overall, the federal bureaucracy has over 20,000 appointed positions.[22] This means that most politicians seek to influence who gets appointed to what. Second, presidents take office without majority support from their party and must build that support by offering cabinet and other positions to other parties in exchange for their votes in Congress on legislation introduced by the president. It is an informal parliamentary system that evolved over time since the return to democracy in 1990 and is now best known by the term coalitional presidentialism.[23]

Coalitional presidentialism means that particularistic interests of politicians in Congress, which may be more interested in distributing pork and patronage than in a long-term innovation policy, will be heavily represented in the Executive branch, including in agencies responsible for planning and deploying innovation policy. Parliamentary particularistic interests compromise the long-term planning necessary to achieve ambitions goals in terms of innovation.

Figure 3 shows the remarkably high levels of average turnover in leadership positions in key, top-level innovation positions. Mean tenure in these 9 positions was 1.9 years, but median

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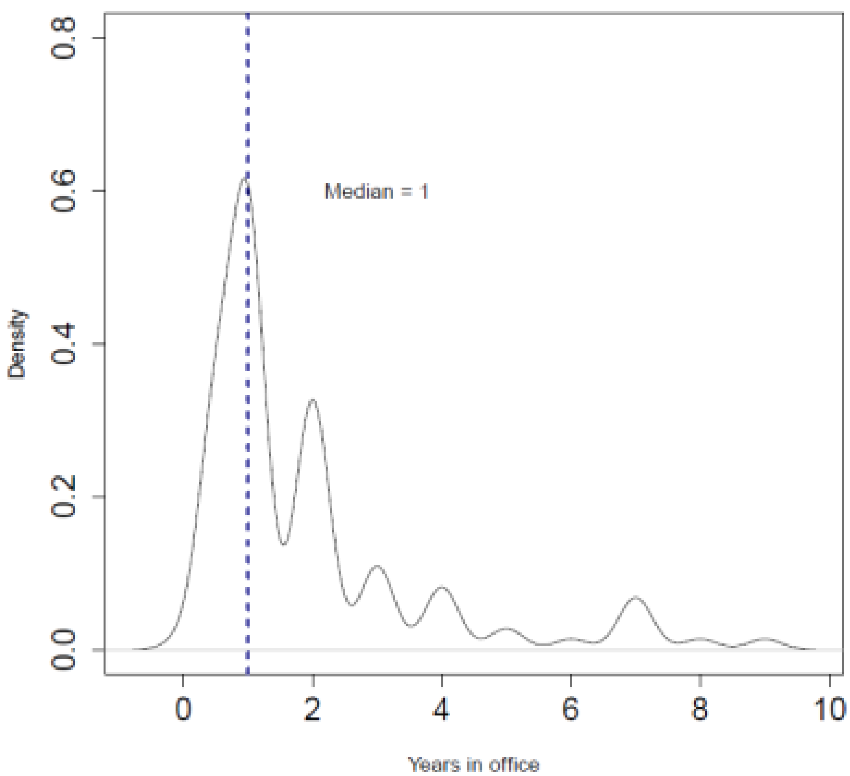
[22] During PT governments, from 2003 to 2013, the number of appointive positions (known as DAS positions), increased from 18,212 to 22,961 (Lopez et al., 2015) as cited in (Lima, 2017a). Many thousands of these positions are filled with career civil servants, but there are still thousands of political appointees (Nunberg and Pacheco, 2016). By contrast the United States fills about 5,000 positions by political appointment, though most European governments appoint only several dozen (Schneider, 1993).

[23] The institutional sources of coalitional presidentialism lie in the electoral system, which is majoritarian for president but proportional for congress. PR naturally fragments parties, as is the pattern in Europe and elsewhere, so that no party has a majority of seats, leaving even the most popular president without majority support from his or her party in congress (Power, 2010; Schneider, 2013, 2016).

tenure was only one year. The mean is pulled up by some outliers like Coutinho (9 years in BNDES) and two ministers of MCT who served 4 and 7 years, but otherwise these agencies have been headed by people who barely had time to figure out what the agencies did, let alone set long term policy. Moreover, most appointees are political. In four top positions in innovation (Presidents of BNDES and Embrapa, Ministers of MCTIC and MDIC), technical appointees headed these agencies for only 22 percent of the years covered.[24]

[24] Presidents of BNDES and Embrapa, Ministers of MCTIC and MDIC.

Figure 3. Tenure Density for Selected Innovation Agencies, 1990-2010?



Periods of time were rounded. Data covers 1985-2016 for President of BNDES, Ministers of MCTIC and MDIC, Presidents of BNDES, Embrapa, Petrobras and FINEP; 2003-16 for Executive Secretaries MDIC and MCTIC; and 2013-16 for Embrapii.

The unfolding Lava Jato scandal reveals the worst aspects of coalitional presidentialism, appointive bureaucracy, and incestuous, illegal business-government relations. The vast majority of kickbacks from Petrobras and other SOEs came on construction and procurement contracts. For the most part Cenpes, Petrobras R&D center, was largely spared, though some large kickbacks came through it. From a spread sheet kept by one of the Petrobras directors coordinating kickbacks, the bribe takers skimmed three percent off downstream construction contracts (refineries) compared to only one percent on upstream equipment contracts for equipment and capital goods (Lima, 2017b). It is easier to hide kickbacks in a construction contract. However, for equipment purchases, it is simpler to check them against international prices. Some of the bribe money went to personal accounts for the politicians and SOE managers involved, but the bulk of it went through campaign contributions and thus helped to manage the high cost of maintaining a legislative coalition.

Widespread corruption has two very damaging effects on innovation policy. First, if business people, especially from the largest firms, know that favorable rulings or policies can be purchased, then powerful business may try to bypass the authority of agencies by resorting to high-profile politicians to bend the rules of innovation policies, or generally escaping the performance standards expected from firms who receive benefits. Second, the existence of huge rents in some parts of government devalue the subsidies provided through innovation policies. In other words, why bother with difficult R&D investment that required lots of paperwork to get subsidized benefits, when firms could buy exclusive benefits easily from ministers or congress members?

The new powers of the judiciary (especially plea bargaining facilities) raised the risks and costs of continuing the sorts of bribery practices uncovered in the Lava Jato scandal. However, this shift did not reduce the costs of maintaining legislative coalitions. Even if illegal funding is not on offer to potential coalition members, presidents will still be pressured to use executive appointments to hold coalitions together which in turn will increase turnover in agencies involved with deleterious effects on long-term policies in areas like infrastructure and innovation.

V. Innovation Vignettes: Policy Dynamics in Innovation Successes

Although it is possible to characterize overall institutional constellations, patterns of collaboration among actors in the innovation ecosystem and outcomes like total R&D, the real dynamics in the system can best be appreciated by delving into micro-level stories that illustrate how various elements combined to produce specific innovation clusters. This section offers very brief vignettes of some of the better known success stories in areas such as soy, aeronautics, ethanol and flex fuel, pharmaceuticals, biotechnology, and the oil and gas supply chain.[25] All involve heavy state investment including subsidized credit from the BNDES, some revolve around sectoral SOEs (Embraer, Embrapa, and Petrobras), most involve universities and public research institutes, but in only a few cases did either domestic firms (pharmaceuticals and biotech) or MNCs take the lead (flex fuel and oil and gas).[26] Table 7 provides a rough overview of the key types of agencies involved. The following vignettes will add nuance to these simple binary distinctions. All of these successes resulted from narrow, targeted sectoral programs, rather than from broad innovation plans or horizontal incentives (like tax deductions for R&D).

Table 7. Key Institutional Actors in Selected Innovation Cases

Sector	**Ministry**	**BNDES**	**Other SOE**	**Finep**	**Regulatory agency**	**University**	**Business**
aeronautics	Airforce	yes	Embraer	yes	--	ITA	--
Soy beans	--	Yes (mechanization)	Embrapa	--	--	Unicamp	--
Pharma-ceuticals	Health	Yes, late	--	Yes?	Anvisa	--	Yes
Oil exploration	--	yes	Petrobras	Yes, late	ANP (local content)	UFRJ	MNCs
Flex fuel	--	--	CTA (minor)	Yes, late?	--	Unicamp	Auto MNCs
biotech	--	yes	--	yes	--	Unicamp	yes

Embraer (*Empresa Brasileira de Aeronáutica*) is the crown jewel of Brazilian innovation. It was not born that way, but rather was an ugly duckling that for decades sucked in subsidies without producing competitive airplanes. Yet, by 2009 it had 17,000 employees and exported over $4 billion. By the late 2000s, Embraer competed head to head with first world companies

[25] Adding in lesser known successes such as banking automation, pulp and paper, steel, and satellite launches would not greatly change the key takeaways from this section of state support within variable institutional constellations (though state "support" for banking automation came partly through hyper-inflation in the 1980s) (Brito and Mello, 2006, 22). On steel and metals, see (Suzigan and Albuquerque, 2011). Tropical medicine is an area of great scientific progress but not commercial success (Suzigan and Albuquerque, 2011).

[26] On university involvement, Suzigan and Albuquerque are categorical: "For each economic or social success case in Brazil, there is a public research institute and/or a university in a supporting role" (Suzigan and Albuquerque, 2011, 4).

(Bombardier), exported 95 percent of its production, led Brazil in manufactured exports, and led the world market for unit sales of regional aircraft (Goldstein, 2008, 58). However, to be in a position to fill this new demand depended on several decades of prior institutional development after the firm's founding in 1969.

Two key factors shaped these early decades. First, the firm was created as an SOE by the Air Force, during military rule, with a clear connection to military goals for national defense, so the firm had strong backers and clear non-commercial goals. For most of its incarnation as a state enterprise, Embraer was subordinate to the Ministry of the Air Force (rather than the Ministry of Industry and Commerce or the Ministry of Mines and Energy, as with most state enterprises) as well as protected by it from intervention by politicians or outside civilian ministries.

Second, other parts of the state offered sustained support. Embraer drew on skilled personnel from the nearby *Instituto Tecnológico da Aeronáutica* (ITA) and *Centro Técnico da Aeronáutica* (CTA).[27] In fact, the training of aeronautical engineers by ITA preceded the establishment of Embraer, and Embraer could also count on ITA later for collaboration in research and development (Goldstein, 2008, 59). In addition, the government (through BNDES) provided subsidized credit to buyers, taxed competing imports, and offered prepayment on government contracts (Avrichir and Caldas, 2005, 49). Much of this government support continued after privatization. Total subsides to Embraer amounted to R$ 142m from 1993 to 2000 (when the real was near parity with the US dollar) (Goldstein, 2008, 59).

One of the main reasons Embraer emerged as a *national* champion is that the government retained a small ownership stake (initially seven percent) and a golden share that granted it veto power over major ownership changes. Moreover, the government stipulated at the time of privatization in 1994 that foreign ownership could not exceed 40 percent. Without these protections, it is not hard to imagine Bombardier or another major foreign producer buying control of Embraer.

[27] ITA and then CTA were Air Force initiatives shortly after World War II designed explicitly to promote the transfer and absorption of technology in Brazil. Both programs developed close connections, and drew heavily on, the aeronautical engineering program at MIT (Avrichir and Caldas, 2005, 49).

Ethanol and Flex fuel autos. By 2011 Brazil had produced over 15 million flex fuel cars – that could run on any mixture of gasoline and alcohol -- that accounted for over half of the light vehicle fleet (Gomez and Legey, 2015, 201). Since 2006, annual sales of flex fuel cars account for 80-90 percent of all cars (Brito, 2009, 4). The impetus for government promotion in ethanol came initially in response to the OPEC oil crisis of 1973. The program known as Proálcool was an initial success in the sense that by the 1980s there were millions of cars on Brazilian roads that ran on pure ethanol. Generous subsidies -- $30 billion dollars in the two decades following Proálcool's creation -- flowed through the sector via subsidies for research and development, for modernizing sugar production, and for lowering the cost of ethanol at the pump (Goldemberg, 2007, 809).

By the late 1990s oil prices started rising again, but consumers were still wary of buying alcohol powered cars, until auto producers came out with flex engine models that allowed them to put any mixture of gasoline and ethanol in the tank. The flex engine had originally been developed in Detroit in 1988, but the cost of the new technology (especially the sensors required to determine the mix of fuel) was prohibitive and the project was shelved. However, engineers at the subsidiary of the German firm Bosch, located near what is sometimes called Brazil's silicon valley in the area around Campinas (and the University of Campinas), assembled a team of 35 scientists and engineers to continue working with the technology and by 1994 had developed software that greatly reduced the cost (see *Veja*, 1 fevereiro 2006, p. 97-8 and (Gatti, 2010)). And, in 2002, the government extended the same tax exemption to flex cars as to alcohol cars (and taxes sometimes amounted to more than a third of the sale price of a new car). In 2003, Volkswagen marketed the first flex car, and within three years nearly three quarters of cars sold were flex.

The other half of the story is availability of ethanol. By the 2000s Brazil was the world's largest producer of ethanol (Brito and Mello, 2006, 13), and the logistics of ethanol distribution were settled, as half of Brazil's 30,000 service stations offered both gasoline and ethanol. Moreover, through research and development, much of it genetic engineering (more below), alcohol yields from sugar cane more than doubled from 1975 to 2004 (Brito, 2009, 8). By 2008, ethanol use surpassed gasoline (Brito, 2009, 1). Brito attributes the productivity to decades of "industrial and academic" R&D (Brito, 2009, 1).[28]

Biotechnology. In the many areas of biotechnology, one that stands out is genome sequencing and subsequent crop modifications in sugar cane. In the early 2000s, Votorantim, one of the largest traditional business groups, created a venture capital subsidiary.[29] Votorantim had a long tradition of entering and exiting sectors and contracted the consulting firm McKinsey to devise a more formal structure and strategy for managing diversification. McKinsey proposed establishing a subsidiary with $300 million to invest in new ventures. So, Votorantim created Votorantim Novos Negocios (VNN) which generated several dozen proposals for diversifying into existing sectors and invested venture capital into 12 new projects (interview with Fernando Reinach, one of the top executives at VNN, 5 July 2011). Eight of these 12 did not pan out; the other four took off. Votorantim sold two of these, Allelyx and Canavialis, to Monsanto and the other two to other investors.

Then, to the surprise of many, by 2010 Votorantim closed VNN despite whopping financial returns (on the order of 60 percent) from the four successful investments. From one perspective, VNN was a failure because the investment (including public funding) did not spawn a national firm with a sustained vocation for R&D and venture capital nor establish a precedent for commodity business groups diversifying into higher technology sectors. From another perspective though, the fact that VNN could sell its startups and make a bundle for itself and the scientists who co-invested sent a clear signal to other would-be innovators that a lot of money could be made in science and engineering (and Fernando Reinach went on to create another venture capital fund with other investors).

Oil and gas. Before the devastation of the Lava Jato scandal, Petrobras had long been a world leader in technologies for deep water oil exploration and exploitation (Lima, 2017b; Randall, 1993). A number of factors went into Petrobras' success in innovation but from an institutional perspective the key is that the success was driven by an SOE. Because Petrobras did

[28] By the 2000s, Brazil lead the world in scientific papers on sugarcane and São Paulo alone published more than any other country (Brito 2009, 9).

[29] The VNN story is from (Schneider 2013).

not produce much oil through the second half of the 20th century, and what it did produce was high cost, Petrobras was not a target for rent seeking as is usually the case in Latin America and became the case for Petrobras in the 2000s after the discovery of massive reserves. Moreover, many groups, including especially the military, pressured Petrobras to find more oil, thus giving strong impetus to its programs to train engineers and collaborate closely with universities like Coppe/UFRJ, invest in R&D (in part through its research center Cenpes, and work with technology leading MNCs (Priest, 2016).

Through the 2000s, Petrobras had to explore and drill in ever deeper off shore waters to get to oil. By the 1990s, Petrobras was close to the world frontier in deep water technology and pushed to go even deeper. Technical staff and researchers and Cenpes took a long term perspective on developing new technologies. In overall institutional terms, this is a story of collaboration of SOEs, universities, and MNCs.

Soybeans. By the 2000s, Brazil's main exports were soybeans and iron ore, which at first glance might seem like the result of Brazil's endowed comparative advantage in natural resources. In fact, traditional soybeans were not at all naturally suited to production in tropical, semi-arid (*cerrado*) areas. It was an SOE in agricultural research, Embrapa (*Empresa Brasileira de Pesquisa Agropecuária*), that adapted seeds and designed practices for reworking soils to make economical production feasible (Figueiredo, 2014; Furquim et al., 2016; OECD, 2015).[30]

In terms of Brazil's complex institutional ecosystem for innovation, the story of soybeans for the cerrado is one of the most narrow as it involved few other institutional actors besides Embrapa. Embrapa has a very decentralized structure with most of its 7,000? Employees distributed across state-level research centers that each focus on agriculture research relevant for the local climate and soils. It is a small agency with a complex structure and local defenders in each decentralized branch, so politicians passed it over. And because the transformation of soybeans was essentially a question of scientific research, it did not require much mobilization of regulatory agencies. However, once the seeds and fertilizers were available, farmers then also need high cost machinery to maximize productivity, and BNDES stepped in with credit. When

[30] Embrapa also participated in national program in 2000s to promote flexing and the production of biodiesel from soybeans as well as other crops. The biodiesel program included a social inclusion provision to source as much as possible from smaller family farms (Paula Pedrotti chapter in gomide) (Oliveira and Schneider, 2016).

the price of soybeans skyrocketed in the 2000s, Embrapa took care of disseminating the technology as farmers scrambled to increase production.

Generic pharmaceuticals. In the 1990s, the pharmaceutical sector in Brazil was dominated by MNCs with a few smaller domestic firms and produced few generic drugs (del Campo, 2016). By the mid 2000s, Brazilian firms rivaled MNCs in overall market share and produced a range of high quality, low cost generics. However, this is a lower level of innovation in that the generics were not new for the world (like Embrapa and Petrobras) but rather new for Brazil. It is also a very different institutional story in that it did not involve SOEs but instead a ministry, regulatory agency, business association, and private domestic firms.

In the 1990s, domestic firms scrambled to adjust to the trade opening, and relied on their business association to provide information and learn collectively to upgrade practices and especially testing. By the late 1990s, the Minister of Health Jose Serra was pressuring domestic firms to substitute for imported drugs. The newly created regulatory agency Anvisa then imposed high testing standards, in effect establishing performance standards on firsm before they started receiving subsidies from the BNDES in the 2000s as part of Pitce (Shadlen and Fonseca, 2013).

In sum, the innovation ecosystem in Brazil has supported a number of world leading technologies from tropical soy to miles underwater oil. Most of these successes stories involved SOEs (Embraer, Petrobras, BNDES, Finep) and universities, some also involved MNCs (flex fuel, deep water oil), and some domestic firms (VNN, generics). What the all had in common was a clear sense of where innovation would take them. These advances were mission driven in that they had goals and could measure tangible progress toward them (Mariana Mazzucato and Penna, 2015). But mission is not enough without protection from politics as Petrobras discovered with Lava Jato. The list of policy failures is much longer and includes earlier phases of ethanol and aircraft production. Market reserve for computers, nuclear energy, Pitce. These were often broad, unfocused promotion policies with the goal of producing innovative industries but without a clear idea of why.

VI. Conclusions

This overview has a statist slant, as it must considering the recent evolution – and probable trajectory – of innovation in Brazil and the ongoing weakness of the private sector in innovation. The institutional overview, as well as the vignettes on innovation successes, emphasized the role of state actors, and especially SOEs. Among SOEs, BNDES lending and Petrobras R&D and local procurement likely injected more funds into innovation than most other sources combined. Officials in the Temer government quickly restricted funding by both SOEs, but it is not yet clear if this will be permanent and if new sources will emerge to supplant these two.

Given the relative success of SOEs and the relative failure of national industrial policies, it is worth speculating briefly on the potential of one of the newest additions to the list of state enterprises participating in industrial policy, Embrapii (Empresa Brasileira de Pesquisa e Inovação Industrial). Created in 2013, Embrapii was designed to support innovation and R&D in private industry using a model based on the Frauenhofer system in Germany (interview João Fernando Oliveira, diretor presidente, Embrapii, 5 November 2014). Embrapii oversees the accreditation of independent research institutes (including public, university, and private institutes). Once accredited, Embrapii makes bloc grants ($10-15 million) that the institutes can draw on once they have matching funds from business partners. Business thus has committed some of its own resources -- skin in the game -- and therefore has incentives to oppose any misapplication of funds.

Compared to other agencies making industrial policy, Embrapii has several other institutional advantages that in principle protect it from political influence. Embrapii has few staff of its own (several dozen) and makes no decisions on which specific projects to fund. It relies on external consultants (from private consulting firms and universities) for accreditation evaluations and follow-up monitoring. And, Embrapii has a large oversight board with representatives from government, business, and academia (Oliveira, 2014). All these institutional features may protect it, however, its funding is limited on both the government and business sides, so, even if successful, its impact on innovation is likely to be modest.

Beyond the usual pathologies of public intervention (delays, red tape, fragmentation), two major problems with the large state role stand out. The first, is disarticulation in the sense that state actors at the core of public innovation activities are not well connected to business and university research, nor do they help much in strengthening bonds between business and universities. No single institutional recipe exists for overcoming this disarticulation; earlier developers found myriad ways to promote collaboration between governments and business (Devlin, 2014; Ornston, 2012). However, it does take time, continuity, and political investment to make any institutional arrangement effective.

The second problem is that innovation policies and funds in the state can get caught up in clientelist distribution and the exigencies of holding together a governing coalition among the main political parties. This latter pressure contributed to high rates of turnover in major government agencies (though with recent exceptions in BNDES and Finep). Admittedly, clientelist politicians are much more interested in big spending ministries like transportation and education, but nonetheless even much smaller ministries like MDIC and MCTIC can be doled out to politicians with no technical qualifications. Short of sweeping political reform, agencies that have kept out of coalition building like Embrapa have done so with strong political backers or more commonly by being too small to attract much political attention. The practical implication is that greater fragmentation and dispersion may in fact provide state agencies greater stability and focus.

Recommending fragmentation goes against a lot of scholarship on innovation policy in Brazil (CNI, 2016). One of the better international models of fragmented yet effective innovation policy is the United States. Of course many other factors went into US policy success, but at least it shows that centralization is not a necessary condition. Another similarity with the United States is that effective policies in Brazil were long term, goal oriented, mission driven sectoral initiatives, not overall innovation programs. In this we echo the recommendation of Mazzucato & Penna (2015) for mission-driven innovation policy, but with the added dimension of fragmentation and added condition of protection from the vicissitudes of coalitional presidentialism.

Glossary

Anatel -- Agência Nacional de Telecomunicações (National Agency for Telecommunications)

Aneel – Agência Nacional de Energia Elétrica (National Agency for Electric Energy)

Anfavea -- Associação Nacional dos Fabricantes de Veículos Automotores (National Association of Automotive Vehicle Manufacturers)

ANP – Agência Nacional do Petróleo, Gás Natural e Biocombustíveis (National Agency of Petroleum, Natural Gas and Biofuels)

Anpei (Associação Nacional de Pesquisa e Desenvolvimento das Empresas Inovadoras, Brazilian Association for Research and Development of Innovative Firms)

Anvisa -- Agência Nacional de Vigilância Sanitária (National Agency for Sanitary Vigiliance)

BNDES -- Banco de Desenvolvimento Econômico e Social (Bank for Economic and Social Development)

CDES -- Conselho de Desenvolvimento Econômico e Social (Council on Economic and Social Development)

Cenpes -- Centro de Pesquisas (Petrobras) (Center for Research)

CNDI -- Conselho Nacional de Desenvolvimento Industrial (National Council for Industrial Development, Brazil)

CNI -- Confederação Nacional da Indústria (Nacional Confederation of Industry)

CPqD -- Centro de Pesquisa e Desenvolvimento em Telecomunicações (Center for Research and Development in Telecommunications)

CTA -- Centro Técnico da Aeronáutica (Technical Center for Aeronautics)

Embraer -- Empresa Brasileira de Aeronáutica (Brazilian Corporation for Aeronautics)

Embrapa -- Empresa Brasileira de Pesquisa Agropecuária (Brazilian Corporation for Agricultural Research)

Embrapii -- Empresa Brasileira de Pesquisa e Inovação Industrial (Brazilian Corporation for Industrial Research and Innovation)

Fapesp --

Fiesp -- Federação das Indústrias do Estado de São Paulo (Federation of Industry of the State of São Paulo)

Finep -- Financiadora de Estudos e Projetos (Funding Authority for Studies and Projects)

FMM – Fundo de Marinha Mercante (Merchant Marine Fund)

FNDCT -- Fundo Nacional de Desenvolvimento Científico e Tecnológico (National Fund for Scientific and Technological Development)

Ipea -- Instituto de Pesquisa Econômica Aplicada (Institute of Applied Economic Research)

ITA -- Instituto Tecnológico da Aeronáutica (Technological Institute for Aeronautics)

MCTIC -- Ministério da Ciência, Tecnologia, Inovações e Comunicações (Ministry of Science, Technology, Innovation, and Communications)

MDIC -- Ministério da Indústria, Comércio Exterior e Serviços (Ministry of Industry, Foreign Trade, and Services)

MEI -- Mobilização Empresarial pela Inovação (Business Mobilization for Innovation)

OECD – Organization for Economic Cooperation and Development

PDP -- Política de Desenvolvimento Produtivo (Policy for Productive Development)

Pitce -- Política Industrial, Tecnológica e de Comércio Exterior (Industry, Technology, and Foreign Trade Policy)

PPB -- Processo Produtivo Básico (Basic Productive Process)

Pro-Genéricos -- Associação Brasileira das Indústrias de Medicamentos Genéricos (Brazilian Association for the Industry of Generic Medicines).

Promef -- Programa de Modernização e Expansão da Frota (Fleet Modernization and Expansion Program)

Prominp -- Programa de Mobilização da Indústria Nacional de Petróleo e Gás Natural (Program for Mobilizing National Industry in Petroleum and Natural Gas)

Pronatec -- Programa Nacional de Acesso ao Ensino Técnico e Emprego (National Program for Access to Technical Teaching and Employment)

Prosoft --Programa para Desenvolvimento da Indústria Nacional de Software e Serviços de TI (Program for the Development of the National Industry of Software and IT Services)

PT -- Partido dos Trabalhadores (Workers' Party)

Senai -- Serviço Nacional de Aprendizagem Industrial (National Industrial Training Service)

Sinaval -- Sindicato Nacional da Indústria da Construção e Reparação Naval e Offshore (National Union of the Naval and Offshore Construction and Repair Industry)

SOE -- state owned enterprise

WTO -- World Trade Organization

References

Araújo, Bruno César et al. (2012). "Impactos Dos Fundos Setoriais Nas Empresas." *Revista Brasileira de Inovação* 11(n. esp.): 85–112.

Armijo, Leslie. (2017). "The Public Bank Trilemma: Brazil's New Developmentalism and the BNDES." In *Democratic Brazil Divided*, eds. Peter Peter Kingstone and Timothy Power. Pittsburgh PA: University of Pittsburgh Press.

Block, Fred. (2008). "Swimming Against the Current: The Rise of a Hidden Developmental State in the United States." *Politics & Society* 36(2): 169–206. http://pas.sagepub.com/cgi/doi/10.1177/0032329208318731 (March 9, 2012).

Brito, Carlos. (2009). "Energy for Development: The Case of Bioenergy in Brazil." In *Wilson Center, Washington DC*,.

Brito, Carlos, and Luiz Mello. (2006). *Boosting Innovation Performance in Brazil*. Paris. http://www.oecd-ilibrary.org/economics/boosting-innovation-performance-in-brazil_357276015553 (October 16, 2016).

Canêdo-Pinheiro, Maurício. 2013. *Inovação No Brasil: Panorama Geral, Diagnóstico E Sugestões de Política?*

Cavalcante, Luiz, and Fernanda De Negri. (2011). *Trajetória Recente Dos Indicadores de Inovação No Brasil*. Brasilia. http://repositorio.ipea.gov.br/handle/11058/1178 (August 14, 2016).

Do Couto e Silva Neto, Fábio et al. 2013. "Patterns of Interaction between National and Multinational Corporations and Brazilian Universities/public Research Institutes." *Science and Public Policy* 40(3): 281–92.

Devlin, Robert. 2014. "Towards Good Governance of Public- Private Alliance Councils Supporting Industrial." (March).

Doctor, M. 2007. "Lula's Development Council: Neo-Corporatism and Policy Reform in Brazil." *Latin American Perspectives* 34(6): 131–48. http://lap.sagepub.com/content/34/6/131.short (October 15, 2016).

Doner, Richard, and Ben Ross Schneider. 2016. "The Middle-Income Trap: More Politics than Economics The Middle-incoMe Trap More Politics than Economics." *World Politics* 68(4): 608–44. https://muse.jhu.edu/article/632355.

Evans, Peter. 1995. *Embedded Autonomy: States and Industrial Transformation.* New York.

http://press.princeton.edu/titles/5690.html (June 23, 2017).

Figueiredo, Paulo. 2014. IRIBA Working Paper : 03 *Technological Catch-up and Indigenous Institutional Infrastructures in Latecomer Natural Resource-Related Industries: An Exploration of the Role of EMBRAPA*.

Frischtak, Claudio, and Katharina Davies. 2015. *Deciphering Brazil ' S Innovation Paradox*.

Furquim, Paulo, MS Saes, PSB Schneider, and TB Carvalho. 2016. *Learning from Productive Development Agencies in Brazil: Policies for Technological Innovation*. Washington DC. https://publications.iadb.org/handle/11319/8020 (June 23, 2017).

Gatti, Wilian. 2010. "A Construção Do Conhecimento No Processo de Inovação: O Desenvolvimento Da Tecnologia Flex Fuel Nos Sistemistas Brasileiros." *Revista Gestão & Tecnologia*: 196. https://www.researchgate.net/profile/Wilian_Gatti_Jr/publication/235900595_O_envolvimento_de_fornecedores_no_desenvolvimento_da_tecnologia_flex_fuel_nas_montadoras_brasileiras/links/0fcfd513f60c821296000000.pdf (October 22, 2016).

Gomez, José M A, and Luiz F L Legey. 2015. "An Analysis of the Impact of Flex-Fuel Vehicles on Fuel Consumption inBrazil, Applying Cointegration and the Kalman Filter." *Energy* 81: 696–705. http://www.sciencedirect.com/science/article/pii/S0360544215000225 (August 16, 2016).

Lima, Renato. 2017a. *The Carwash Pandora's Box: Business-Government Relationship in Brazil*.

———. 2017b. "The New Politics of Oil: Industrial and Technology Policy in Brazil, Mexico, and Malaysia." MIT.

Mazzucato, M. 2015. *The Entrepreneurial State: Debunking Public vs. Private Sector Myths*. https://books.google.com/books?hl=en&lr=&id=KQMrCgAAQBAJ&oi=fnd&pg=PT8&dq=mazzucato,+mariana&ots=ZygAoSVVRV&sig=4dB0oE_wypfbLmTqYnJHyeBpb-A (June 9, 2017).

Mazzucato, Mariana, and Caetano C R Penna. 2015. "The Rise of Mission-Oriented State Investment Banks: The Cases of Germany ' S KfW and Brazil ' S BNDES Mariana Mazzucato." 26.

Melo, Luiz Martins de. 2009. "Financiamento À Inovação No Brasil: Análise Da Aplicação Dos Recursos Do Fundo Nacional de Desenvolvimento Científico E Tecnológico (FNDCT) E Da Financiadora de Estudos E Projetos (FINEP) de 1967 a 2006." *Revista Brasileira de Inovação* 8(1 jan/jun): 87–120.

De Negri, Fernanda. 2012. "Elementos Para a An{á}lise Da Baixa Inovatividade Brasileira Eo Papel Das Pol{í}ticas P{ú}blicas." *Revista USP* (93).

de Negri, João, Mauro Lemos, and Fernanda De Negri. 2006. *The Impact of University Enterprise Incentive Program on the Performance and Technological Efforts of Brazilian Industrial Firms*. Washington, DC.

Nunberg, Barbara, and Regina Pacheco. 2016. "Public Management Incongruity in 21st Century Brazil." In *New Order and Progress:*, ed. Ben Ross Schneider. New York: Oxford University Press. https://books.google.com/books?hl=en&lr=&id=exXoCwAAQBAJ&oi=fnd&pg=PA134&dq=nunberg+pacheco&ots=ufMDjmEw3L&sig=eg3ADLgBANOx4kTnvgNYKTPw7m4 (June 24, 2017).

OECD. 2015. *Innovation, Agricultural Productivity and Sustainability in Brazil*. Paris: OECD.

Oliveira, Gustavo, and Mindi Schneider. 2016. "The Politics of Flexing Soybeans: China, Brazil and Global Agroindustrial Restructuring." *The Journal of Peasant Studies*.

Ornston, Darius. 2012. *When Small States Make Big Leaps : Institutional Innovation and High-Tech Competition in Western Europe*. Ithaca: Cornell University Press. https://www.amazon.com/When-Small-States-Make-Leaps-ebook/dp/B008NAZZ90/ref=sr_1_1?s=books&ie=UTF8&qid=1488822517&sr=1-1&keywords=9780801465529 (March 6, 2017).

Pack, Howard, and Kamal Saggi. 2006. "Is There a Case for Industrial Policy? A Critical Survey." *World Bank Research Observer* 21(2): 267–97. http://wbro.oxfordjournals.org/cgi/doi/10.1093/wbro/lkl001 (October 4, 2013).

Power, Timothy. 2010. "Optimism, Pessimism, and Coalitional Presidentialism: Debating the Institutional Design of Brazilian Democracy." *Bulletin of Latin American Research* 29(1): 18–33. http://onlinelibrary.wiley.com/doi/10.1111/j.1470-9856.2009.00304.x/full (March 7, 2014).

Priest, Tyler. 2016. "Petrobras in the History of Offshore Oil." In *New Order and Progress*, ed. Ben Ross Schneider. New York: Oxford University Press.

Randall, Laura. 1993. *The Political Economy of Brazilian Oil*. Wastport CT: Praeger.

Schneider, Ben Ross. 1991. *Politics within the State: Elite Bureaucrats and Industrial Policy in Authoritarian Brazil*. Pittsburgh PA: University of Pittsburgh Press. https://books.google.com/books?hl=en&lr=&id=X-Wy10tn66wC&oi=fnd&pg=PR7&dq=Ben+ross+schneider&ots=bHxYSjPaJF&sig=HjUzOSLE3ZMGGa5J4e0vOnOr8cM (June 4, 2016).

———. 1993. "The Career Connection: A Comparative Analysis of Bureaucratic Preferences and Insulation." *Comparative Politics* 25(3): 331–50.

———. 2013. *Hierarchical Capitalism: Business, Labor, and the Challenge of Equitable*

Development in Latin America. New York: Cambridge University Press. https://scholar.google.com/scholar?q=ben+ross+schneider&btnG=&hl=en&as_sdt=0%2C22&as_ylo=2012#3 (February 9, 2016).

———. 2015a. *Designing Industrial Policy in Latin America*. New York: Palgrave Macmillan. http://www.palgraveconnect.com/doifinder/10.1057/9781137524843.0005 (October 16, 2016).

———. 2015b. *Politics, Big Business, and Industrial Policy in 21st Century Brazil*.

———. 2016. *New Order and Progress: Development and Democracy in Brazil*. New York: Oxford University Press. https://books.google.com/books?hl=en&lr=&id=A1MvDAAAQBAJ&oi=fnd&pg=PP1&dq=ben+ross+schneider&ots=oNSYjayg4v&sig=mw0s-AqA8nLwdlA5Qq_Yasu-NJo (October 16, 2016).

Shadlen, Kenneth, and Elize Fonseca. 2013. "Health Policy as Industrial Policy: Brazil in Comparative Perspective." *Politics & Society* 41(4): 561–87. http://journals.sagepub.com/doi/10.1177/0032329213507552 (June 13, 2017).

Stallings, Barbara. 2016. "Innovation, Inclusion, and Institutions: East Asian Lessons for Latin America?" In *Innovation and Inclusion in Latin America*, Palgrave Macmillan. http://link.springer.com/chapter/10.1057/978-1-137-59682-6_1 (October 15, 2016).

Suzigan, Wilson. 2011. "O Perfil Das Interações de Universidades E Empresas No Brasil a Partir de Alguns Segmentos Da Indústria*." : 1–15.

Suzigan, Wilson, and Eduardo Albuquerque. 2011. "The Underestimated Role of Universities for the Brazilian System of Innovation." *Revista de Economia Política* 31(1): 03–30. http://www.scielo.br/scielo.php?pid=S0101-31572011000100001&script=sci_arttext (October 24, 2016).

Tavares, José. 2015. "O Enigma Da Política Industrial No Brasil." *Revista de Economia Política* 35(3): 461–74. http://www.scielo.br/scielo.php?pid=S0101-31572015000300461&script=sci_arttext (June 9, 2017).

Taylor, M. Zachary. 2016. *The Politics of Innovation: Why Some Countries Are Better than Others at Science and Technology*. New York: Oxford University Press. https://books.google.com/books?hl=en&lr=&id=cUcnDAAAQBAJ&oi=fnd&pg=PP1&dq=zachary+taylor+innovation&ots=HBI0A-jg5k&sig=oXw8QeAIJJTk1ux0VUDdrcgW0s0 (June 13, 2017).

Weyland, Kurt. 1998. "From Leviathan to Gulliver? The Decline of the Developmental State in Brazil." *Governance* 11(1): 51–75. http://dx.doi.org/10.1111/0952-1895.571998057 (October 17, 2016).

Worldbank. 2017. *Productivity in Brazil*. Brasilia: World Bank.

Zuniga, Pluvia et al. 2016. *Conditions for Innovation in Brazil: A Review of Key Issues and Policy Challenges*. Brasilia.