CHAPTER

3

Industrial Policy and Structural Transformation of Brazilian Economy

Nobuaki Hamaguchi

1. Introduction

Structural transformation is a critical concept in economic development. A society develops as it turns from a simple economy based on agriculture and handcraft to an economy with higher complexity and larger scale industries. The introduction of new technology enables us to achieve higher labor productivity. The creation of a new industry expands the division of labor. Thus, we benefit from less time tied to work for higher incomes, and enjoy a greater variety of consumption.

Governments may want to accelerate the process of such structural transformation by intervening in resource allocation. Industrial policy is the general term for such measures to protect and nurture specific types of industries, mobilize labor and capital from one sector to another, and establish necessary institutions and a legal framework. Similar to 'market vs. state' arguments, industrial policy receives support and criticism on both technical and ideological grounds.

Brazil, which we study in this chapter, is a thought-provoking case for this debate. Brazil implemented comprehensive industrial policies over a long period of time. In the Golden Age, industrial policy was a driving force of Juscelino Kubitschek's national integration (1956-61) and the growth miracle (1969-73) under the military regime. Over the years, industrial policies have changed directives, configuration, focus, and range, reflecting developmental challenges at times. Our objective is to understand the specific contexts in which adjustments to industrial policies were made, reflecting the structural transformation of the Brazilian economy. Industrial policy in the contemporary globalized market economy is a relevant attempt to break through the ceiling of a premature deindustrialization, which is a common symptom among

emerging economies. We may draw some lessons from the recent experiences of Brazil.

The chapter is organized as follows. Section 2 provides a review of economists' arguments on industrial policy. Section 3 summarizes the structural transformation of the Brazilian economy using the data of GDP, international trade, and innovation activities. Section 4 tracks industrial policies from the inauguration to the collapse of import-substitution industrialization, supporting the structural transformation. Section 5 discusses the rejuvenation of industrial policy in the twenty-first century with a well-structured framework. The final section concludes the discussion.

2. Review of Literature

2.1. Pros and cons of industrial policy

There is a long debate among economists as to whether or not a country should implement industrial policy. The Nobel laureate Gary Becker famously claimed that 'an industrial policy would become a servant of special interests rather than a guardian of the general interest' (Becker 1985, 8).[1] A negative perception toward industrial policy is presented even in the literature of development economics for which structural transformation is fundamental (Harrison and Rodriguez-Clare 2010). However, another Nobel laureate Joseph Stiglitz (2017, 23) defends the role of industrial policy in development strategy, commenting that, 'the market may not lead to either a good allocation of resources among sectors or the appropriate choice of techniques. Industrial policies, aimed at affecting the economy's sectoral allocation and choice of technique, are one of the instruments for addressing these market failures.'

Rodrik (2008) argued that the debate on industrial policy should not be *whether to* implement it. Instead, it should be normalized to discuss *how to* apply it like any other government intervention in health, education, social insurance, or macroeconomic stabilization. The main reason for his argument is that scale economy, information asymmetry, poor coordination, and externalities cause market failures that hinder structural transformation and technological upgrading, making a strong

[1] The same phrase was used by former Brazilian Minister of Finance Pedro Malan of the Fernando Henrique Cardoso administration.

case for policy intervention. Weak learning by doing, lacking industrial agglomeration, and financial disintermediation are typical shortcomings of the market. They cannot be addressed without departing from the assumption of perfect competition.

A common criticism against industrial policy identifies government failures as more problematic than market failures. Discretional resource allocation with a political objective invites corruption and rent-seeking.[2] Besides a political bias, the government is less efficient than a market to choose which sector or activity to be fostered because of incomplete information. Rodrik (2008) challenges this view that it is possible to design institutional arrangements that achieve social objectives of economic development while handling well some potential problems arising from an intervention.

Concerned with selective biases, some prefer horizontal measures that are unselective of sectors. These include general support for research and development (R&D), nurturing business environment through capital market development, science education programs, and the development of information technology infrastructure. However, even the measures considered horizontal cannot be viewed as unselective because more capital- and research-intensive sectors will receive more benefits. After all, any support for structural change and productivity growth cannot serve as a policy goal without any consideration of the direction of technological change (Aiginger and Rodrik 2020).

2.2. Industrial policy beyond market failures

Mazzucato (2011) further argued that just fixing market failures is not enough. She stands for an entrepreneurial government that shows directions, areas, and routes towards new 'techno-economic paradigms.' For Mazzucato (2015), the rationale for industrial policy is to transform, to catalyze, and to shape the market rather than to fix its failures alone. In the same vein, Andreoni et al. (2019) criticized the discussion of an industrial policy that centers the problem of market-failure on the basis of open and competition-based market structure. They argue that the

[2] See also Ades and Di Tella (1997). They point out that active industrial policy increases both investment and corruption. But because the latter deters investment, the effects of industrial policy on investment suffers a loss, even when the total effect would be positive.

debate loses contact with the historical and context-specific dynamics and the political economy of production transformation. Then, we may miss an integrated policy framework, considering micro-, meso (sector)-, and macro-structures, and interdependence between those levels.

Landesmann and Stöllinger (2019) developed the notion of 'appropriate innovation policy' from the viewpoint of context-specific policy design. Industrial policy in developed countries places weight in innovation, while economies that are catching-up focus on faster upgrading (product upgrading, process upgrading, functional upgrading, and value-chain upgrading). If a country is further away from the technological frontier, a state may want to take advantage of backwardness by facilitating technology transfer and building the capacity of learning. In the current period where global value chains play an essential role in defining the international division of labor, a necessary role of the government is to attract foreign firms as the primary agents of the diffusion of internationally generated knowledge. When a country comes closer to the global technology frontier, the government switches its emphasis to R&D capacity building. Failure in designing context-specific policies prevents a country from climbing the development ladder and keep it in the 'middle-income trap.' Wade (2016) argues that industrial policy with sectoral targets that takes maximum advantage of occasional opportunity and original potential can help to accelerate a middle-income country into the high-income segment.

2.3. Technological revolutions and coordination for structural transformations

The technological revolution drives structural transformations of an economy and the society as a whole. As Table 3.1 shows, through the spread of agricultural technology, the productivity of food production jumped significantly, allowing for population growth and the formation of settlements. The invention of a steam engine in the late 18th century initiated the first industrial revolution wherein the production modality shifted from handcraft to mechanization. The second industrial revolution in the late 19th century was based on the change of energy source to petroleum and electricity, allowing for the use of high-powered machinery to realize mass production. The advance of digital technology beginning in the 1990s led to the third industrial revolution, in which exponential development of processing and transmission of data was enabled through

Table 3.1. Technological Paradigm Change

Society	Technological revolution
1. Hunter and gatherer society	
	Agricultural revolution (Farming and cattle raising, High food productivity, population growth, human settlement)
2. Agricultural society	
	I. Industrial revolution (Steam engine, mechanize production) II. Energy revolution (Electric power and internal combustion engines, Mass production)
3. Industrial society	
	III. The digital revolution (personal computer, service innovation)
4. Information society	
	IV. Information and telecommunication technology revolution
5. Smart society	

Source: Author's elaboration based on Schwab (2015). About Society 5.0 Cabinet Office of Japan. https://www8.cao.go.jp/cstp/english/society5_0/index.html.

intensive use of personal computers connected through the internet.

Schwab (2015) argues that the most recent development of digitalization and communication speed will lead to the fourth industrial revolution. We can already witness new combinations of hardware and software that are flourishing, such as artificial intelligence, robotics, block-chain, internet-of-things (IoT), fintech, 3D printer, etc. Wade (2016) points out that digital technology is entering highly regulated markets such as healthcare, transport, energy, and education, hence the potential contribution of industrial policy agencies is all the greater today. Slower digitalization progress in these areas contrasts to the current information society era where global champions in the digital revolution emerged from the free competition in unregulated new businesses, notably GAFA (Google, Amazon, Facebook, and Apple). The Japanese government aims for the post-information society (Society 5.0), emphasizing human-centered use of new technologies.

History shows that crucial technologies that have catalyzed structural transformations have been supported by public policy. To begin with, the British government passed an Act of Parliament in 1775 to give Watt a 25 year monopoly on producing steam engines. Oil and gas, electric power generation, railroad, telecommunication, internet, information

technology, biotechnology, and nanotechnology also received protection and promotion from the government in developed countries.[3] Japan has been considered a hallmark of a successful industrial policy in the catch-up phase. It used: (i) horizontal measures (promotion of science and technology and broad education and training opportunities); (ii) targeted sector policies (state-led investment, enhancement of private enterprise R&D and new technology adaption, economic signals and incentives to profit-motivated agents through pricing, import tariffs, and quotas, and the regulation of competition); and (iii) information sharing and coordination (Cimoli et al. 2015).

These historical accounts suggest that the government is a strong (if not the only) candidate for attending to the problem of failed coordination arising from high uncertainties during the adaptation to revolutionary technological change (Matsuyama 1997).

2.4. Industrial policy for learning

We can characterize catching-up as a process of learning to narrow the gap from the international technology frontier. There are two ways of learning: learning by doing and learning from others. Some countries learn more rapidly than others. To explain such differences, Oqubay and Ohno (2019) present views on a national systemic aspect of learning with government leadership beyond individual people and firms. The role of the government includes presentation and sharing of a vision, planning with a definite time-, priority-, and budget-setting, nurturing of trust with a clear rule of competition, evaluation of achievements, and allocation of benefits.

Peres and Primi (2019) point out that Latin American countries have historically been prone and open to learning from others, but learning by doing has been weak. They point out the shortcomings including the following aspects: political leaderships to ensure continuity; managerial and technical capacity in the government to implement and evaluation

[3] The digital economy in the US since late 20th-century benefitted from the initial support of the Regan Administration: human genome project at Federal labs, semiconductors via SEMATECH, and the computer industry via Strategic Computing Initiative, the launch of The Small Business Innovation Research (SBIR) program in 1982, which shielded US high-tech industries from foreign competition; the Hatch-Waxman Act in 1984, which helped create the generic pharmaceutical industry.

policies; a coherent policy mix with clear priorities and recognition of tradeoffs and synergy; and a mechanism to carry out a constructive dialogue among stakeholders in government (central and regional) and private (domestic and foreign) sectors.

In these respects of valuing technological capability, research on the industrial policy may find a new direction. Aiginger and Rodrik (2020) appeal that industrial policy needs a new conception that addresses the need to nurture and develop modern economic activities more broadly, which may be nicknamed 'productive development policies,' 'structural transformation policies,' or 'innovation policies.'

2.5. Implications from the literature review

Previous studies reviewed in this section reveal that industrial policy have wider functions than the government to change a resource allocation for which the market could do a better job. Industrial policy complements the market mechanism by remedying market failures and enhances the efficiency of the market through horizontal measures.

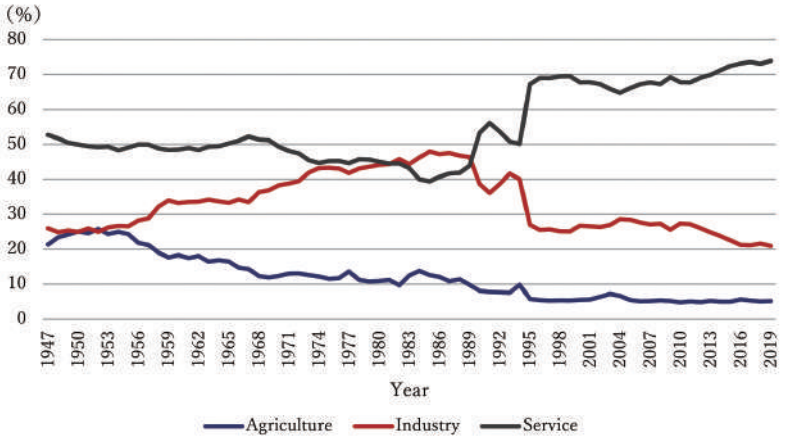
We noticed that industrial policy is also able to adapt the economy to both internal and external change in techno-economic paradigms by giving clear directives when economic agents might be perplexed by high uncertainties needing coordination. The government is also able to show directions and the route toward a structural transformation to encourage continuous learning to build a stronger technological capability and constructive dialogue among stakeholders.

Effective function of such a steering role of the government requires strong institutional capability of the public sector in policy-formulation, project-execution, and performance-evaluation. It also calls for a political integrity and a democratic institution. Finally, industrial policy demands continuity, which duely depends on the maintainance of macroeconomic balance. Hence, the goal must be realistic under the financial capability of the government.

3. Structural Transformation of the Brazilian Economy

3.1. Structural transformation seen in sectoral shares of GDP

We can see in Figure 3.1 two phases of the structural transformation of



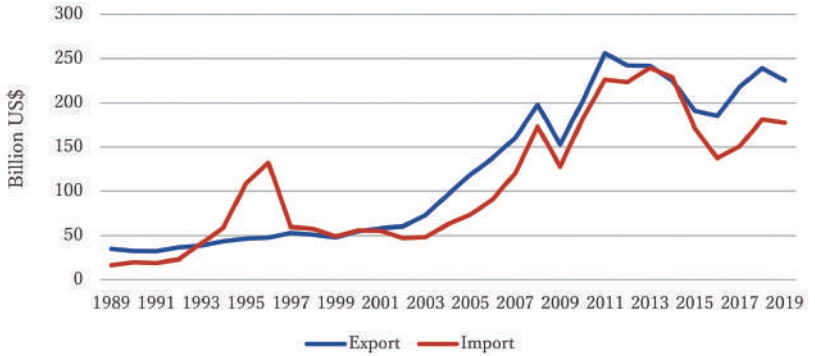
Note: According to IPEADATA, until 1994, the sum of the values added in the three major sectors (agriculture, industry, and services), reported originally by IBGE, exceeds the total GDP at basic prices, which also includes a fictitious sector with negative GDP (since there is no production, only intermediate costs) called dummy financial or allocation of financial intermediation services. We maintain the percentages as published by IPEADATA and, therefore, the three major sectors add up to more than 100 per cent until 1994.
Source: Author's based on IPEADATA.

Figure 3.1. Sectoral Shares of GDP: Agriculture, Industry, and Service

the Brazilian economy since the end of World War II. During the first phase until the mid-1980s, the GDP share of agriculture continuously fell, and that of industry rose, while service maintained a constant share. This phase is the period of rapid industrialization supported by active industrial policies and development planning.

The second phase after the mid-1980s saw the rise of the service sector and the decline of industry, while agriculture always remained below a 10 per cent share. This period can be further divided into three sub-periods; the sharp drop of industry's share from the mid-1980s to the mid-1990s; stability from the mid-1990s to the end of the 2000s; and further decline of the industry since 2010. As described below, the first sub-period shows the contraction of industry amidst the economic crisis to relinquish industrial policies which had boosted industries in preceding periods. After the stabilization and restoring economic growth in the second, the third sub-period demonstrates the symptom of 'Dutch disease' type premature deindustrialization (de Paula 2017).

After decreasing as a share of GDP in the early 1990s, imports increased



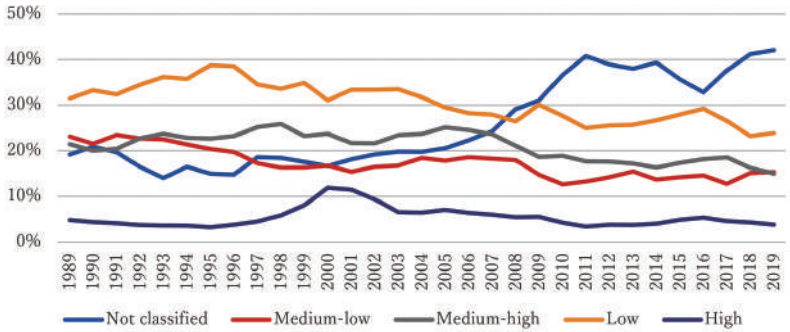
Source: Author's elaboration based on the data from Comex Stat, Ministério da Economia Indústria, Comércio Exterior, e Serviços.

Figure 3.2. Exports × Imports – 1989-2019

sharply, as we see in Figure 3.2. Trade liberalization and subsequent overvaluation of the currency caused the deterioration of the trade balance (Amann and Baer 2000). Competition from an oversaturated imports market deterred domestic industries. Then, commodity prices started to rise around 2000, which boosted Brazilian exports. During the period of the commodity boom, while the penetration of imported industrial goods had become more pronounced, certain types of manufacturing production for the growing domestic market expanded. The automobile industry was the most notable example of the latter. Hence, the industry's GDP remained stationary while the commoditization of exports advanced. Deindustrialization became noticiable in the 2010s as the domestic market shrunk because the commodity boom ended in the face of economic growth deceleration in China.

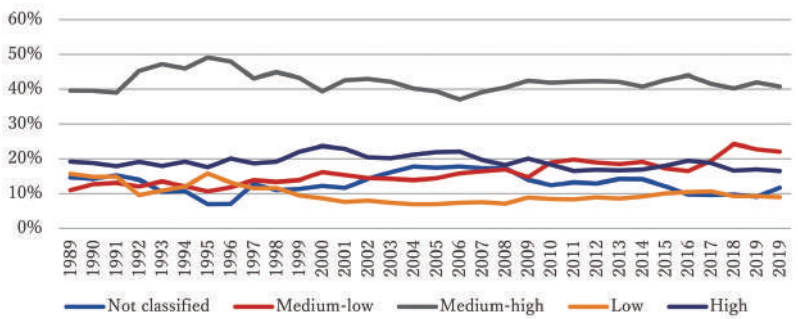
3.2. Trade composition transformation

We can reinforce the argument of the premature deindustrialization in Brazil with data on the composition of international trade. Figures 3.3 and 3.4 respectively show shifting patterns in the structure of exports and imports. Exports and imports are categorized here by the intensity of technological elements in the traded items following the classification made by the Brazilian Ministry of Economy, from which we obtained the Standard International Trade Classification (SITC) two-digit level trade data. Namely, each group is composed by the following sectors: (i) Aircrafts, Informatic equipment & Electronic and optical products, and



Source: Author's elaboration based on the data from Comex Stat, Ministério da Economia Indústria, Comércio Exterior, e Serviços.

Figure 3.3. Composition of Exports by Technological Contents



Source: Author's elaboration based on the data from Comex Stat, Ministério da Economia Indústria, Comércio Exterior, e Serviços.

Figure 3.4. Composition of Imports by Technological Contents

Pharmaceutical products are *High technology*; (ii) Cork coal, Petroleum derivatives & Biofuel, Ships, Metal, Rubber & Plastic products, Metal products, and Nonmetal mineral products are *Medium-low technology*; (iii) Electric machine, tools & parts, Other machine & equipment, Chemical products, Automotive vehicles, and Railroad vehicles and other transport equipment are *Medium-high technology*; (iv) Clothing & Accessories, Beverage, Paper & Cellulose, Leather products, Printing & Recording, Wood products, Furniture, Food, Tobacco, and Textile are *Low technology*; (v) Agriculture & Livestock, Fishery & Aquaculture, Recycling & Waste, Electricity & Gas, Extract of Coal, Metal Minerals, Non-metal Minerals, & Oil and Gas, Cinematography, Video & Editing are a group that is *Not classified in terms of technology*.

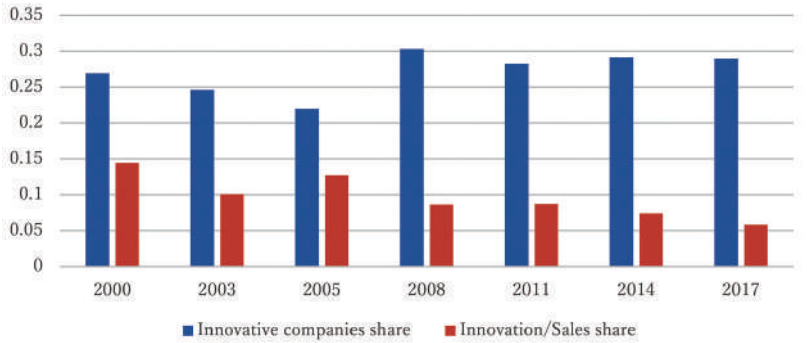
A striking feature of Brazilian exports is a remarkable increase in natural resource-based exports, which is in the *Not classified* group in Figure 3.3. On the other hand, the shares of *Low and Medium-high technology* groups were in a dominant position until the 1990s when they began to decline. It was the *Low and Medium-low technology* group which first lost the share in the late 1990s because of currency overvaluation. *Medium-high technology* products, most notably automotive vehicles, could strive for the first half of the 2000s. They were based on the intra-regional trade of MERCOSUR protected by a relatively high common external tariff. Still, the share has declined in the recent period because of the downturn of the Argentinian economy.

On the import side, Figure 3.4 reveals the predominance of the share of *Medium-high technology* products. Within this group, intermediate goods, most notably electronic parts and components and chemical products, have great importance. It is also worth mentioning that the share of *Medium-low technology* products is increasing. Despite import substitution efforts in previous periods, local intermediate goods were replaced by foreign substitutes, which are cheaper and of higher quality. Global competition made this phenomenon more visible. Castillo et al. (2019) corroborate that import penetration of intermediate goods rose significantly in recent years within the global value chain.

3.3. Innovation activities

Alongside an overvalued currency, underperforming innovation was another factor in the weak competitiveness of the Brazilian manufacturing industry. IBGE (Brazilian Institute of Geography and Statistics) conducts a Survey of Innovation (PITEC) every three years to collect the data on innovation activities of Brazilian firms. PINTEC is a survey of firms with ten and more employees from mining and manufacturing, stratified by location, activity category, and firm size conducted in 2000, 2003, 2005, 2008, 2011, 2014, and 2017. ICT related service has been included in PINTEC since the 2005 survey. PINTEC's definition of innovation activity is not restricted to internal R&D. Still, it includes a broad range of actions such as the acquisition of external R&D, external knowledge, software, and machines and equipment; training of personnel; market research; and production process changes.

Figure 3.5 depicts that the proportion of firms engaging in innovation



Source: Author's elaboration based on PINTEC.

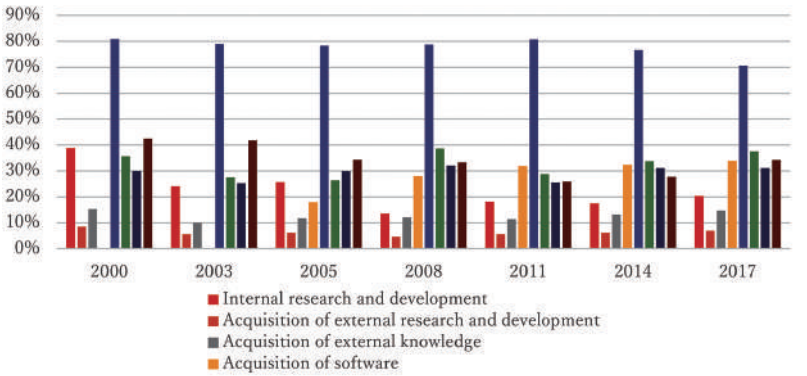
Figure 3.5. Share of Firms Engaging in Innovation Activities and Average Innovation Expenditure to Sales

remains below 30 per cent. We should also note that this proportion rose slightly since 2008 compared to the previous years. However, the size of expenditures for innovation activities as a proportion to total sales declined.[4] This suggests that more firms have engaged in innovation activities recently, but the scale of these activities is lower than in the past.

From Figure 3.6, we can infer the following. For Brazilian firms, the acquisition of machines and equipment is the dominant concept of innovation activity. The acquisition of software is also a growing concept. That is, Brazilian firms introduce new technologies mainly by acquiring new equipment and software, in which new technologies are readily embodied. In the meantime, the share of firms engaging in internal R&D declined. However, a glance at Figure 3.7 reveals that the expenditure share for internal R&D has increased over the period, compared to other types of innovation activities. This suggests a concentration of internal R&D to fewer firms.

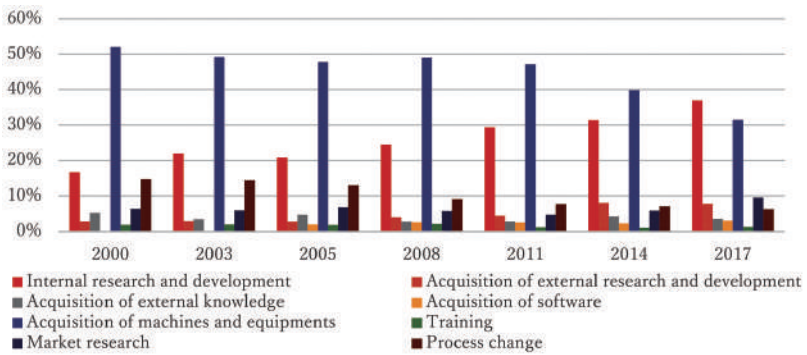
In sum, the Brazilian economy made a structural transformation, first as the industrial sector dominated over the agricultural, and then later as the service sector occupied the dominant share of the economy (Figure 3.1). Although it appears to be a natural development process,

[4] We first calculated average per firm innovation expenditure share as (total innovation expenditure)/(total number of firms engaging in innovation). Average per firm sales is obtained by (sales of all firms)/(total number of firms). We obtain innovation expenditure as a proportion of sales by dividing the former by the latter.



Note: The acquisition of software was included in the research in 2005.
Source: Author's elaboration based on PINTEC.

Figure 3.6. Shares by Type of Activity among Firms Who Declared to Practice Innovative Activities



Note: The acquisition of software was included in the research in 2005.
Source: Author's elaboration based on PINTEC.

Figure 3.7. Innovation Activity Expenditure Shares by Type of Activity

industrialization was strongly boosted by industrial policies, and the recent deindustrialization seems premature (de Paula 2017). The shrinking of the industry can be viewed as premature in two senses: it occurs at a considerably lower level of income, and it has detrimental effects on economic growth (Rodrik 2016). Regarding the latter, the Brazilian case shows that the industry failed to develop higher technology content and extensive innovation activities.

Some questions may follow. First, if deindustrialization was premature,

how did industrial policies affect that consequence? Second, if trade liberalization triggered deindustrialization, how were industrial policies adapted to the new situation, and what was their impact? We will consider these questions in the subsequent sections.

4. Industrial Policies in Brazil in the Past

4.1. The Vargas era: start of the import-substitution industrialization, the 1930s-1950s

Initial attempts at industrial policy in Brazil were seen in the strategy of catch-up industrialization of the Getúlio Vargas administration in the 1930s–50s. Under the strong postulate of the authoritarian populist regime, Vargas aimed at 'complete economic independence' 'through the establishment of the national steel industry.' He took advantage of America's concern over Nazi cooperation in Brazil's steel plans to draw from Washington needed help for equipment and loans (Hilton 1975). Under his government, the Volta Redonda (Rio de Janeiro State) plant of Companhia Siderúrgica Nacional (CSN) and the iron ore exploration in Minas Gerais State of Companhia Vale do Rio Doce (CVRD) were established in the 1940s. Other institutional developments under Vargas was the establishment of the National Petroleum Council (CNP) in 1938, nationalizing petroleum, the National Economic Development Bank (BNDE)[5] in 1952, and the state-owned oil company Petrobras in 1954. These were ad-hoc measures and rather than a set of coherent import substitution industrialization (ISI) policies.

ISI gained shape as a more systematic development strategy in the post-World War II era (Baer and Kerstenetzky 1964). At that time, the lack of foreign currency to import essential intermediate goods was the major constraint for industrial development. To overcome the difficulty, the import licensing system and multiple exchange rate regimes were introduced. Import limitation was amplified from 'nonessential' consumer goods to most of the domestically produced industrial products (Law of National Similar, Lei 2973, 1956.11.26).

[5] BNDE was renamed as National Economic and Social Development Bank (BNDES) in 1982 with the incorporation of the Social Investment Fund.

4.2. First comprehensive ISI plan: Plano de Metas, 1956-61

President Juscelino Kubitschek took power in 1956 in the intense political instability after the suicide of Vargas in 1954. He pledged national economic integration and 30 development goals to realize '50 years economic progress in 5 years,' known as Plano de Metas (Plan of Targets). Those goals were based on previous studies elaborated by the Brazil-US Mixed Commission (1951-54) and the BNDE- ECLA (Economic Commission for Latin America of the United Nations) Mixed Group (1953-57). Both studies aimed at streamlining some bottlenecks of economic development in Brazil, though from different perspectives.

The Brazil-U.S. study focused on addressing deficiencies in domestic transportation (especially railroads), developing potential in electric power generation and petroleum, and enhancing productivity in agriculture, livestock, forestry, and mining. The Brazil-U.S. study was based on the unbalanced-growth model by Gunnar Myrdal and Albert O. Hirschman, which emphasize the necessity of big-push and the interplay of backward- and forward linkages.

The BNDE-ECLA study, while recognizing the necessity to fulfil the gap in essential services such as transportation and energy, highlighted ISI on capital goods and intermediate goods. The study was based on the balanced-growth model represented by Paul Rosenstein-Rodan and Ragnar Nurkse, who contend that all inter-linked sectors should grow concertedly. The two studies presented different opinions regarding the use of foreign capital. While both studies agreed on the point that insufficient domestic savings and balance of payments constraint are central problems for the economic development of Brazil, the Brazil-U.S. study recommends more inflow of foreign capital. On the other hand, BNDE-ECLA saw foreign capital as a negative because it transfers scarce foreign currency overseas in the form of profit repatriation.

In Brazil, Roberto Campos belonged to the unbalanced-growth camp, and Celso Furtado was a proponent of the balanced-growth model. The Plan of Targets was born as a mixture of the two distinct types of development strategies. It focuses on energy (electric energy, nuclear energy, coal, petroleum production, and refining) and transport infrastructure (railroad repairs and construction, port and dredging, maritime transport, air transport), which were considered essential bottlenecks for development.

The Plan also included other sectoral plans for agriculture and food (wheat production, grain storage, cold meet storage, slaughterhouse, agriculture mechanization, fertilizer), essential materials (steel, aluminium, ferrous metals, cement, chlorine, paper and pulp, rubber, iron ore export), and capital goods (automobile industry, naval construction, heavy electric materials, and machinery).

Foreign capital received favorable treatment in essential materials and capital goods industries as the source of capital and technology. For energy and infrastructure development, the government became primarily responsible for execution. BNDE formulated investment plans, set priorities, and supplied financing to projects, capitalizing resources through the addition of corporate income tax and aid from the United States.

Despite the recommendation of the Brazil-U.S. Mixed Commission to prioritize railways, the government preferred roads as the main means of transportation and promoted the installation of the automobile industry. The Brazilian government banned all car imports in 1956. Foreign automobile companies had to choose either to abandon the Brazilian market or to invest in producing cars within five years.

Implanting the automobile industry in Brazil was one of the promises of Juscelino Kubitschek during his presidential election campaign. Soon after coming into the power, Kubitshcek launched the Executive Group of Automotive Industry (GEIA) headed by civil engineer Lucio Meira. Because Kubitschek insisted that national production of an automobile must start as soon as possible, GEIA intended to attract foreign assemblers to install full-fledged production units in Brazil. At the same time, because of the stringent balance of payments constraint, GEIA did not admit most parts imported and decreed that 90 to 95 per cent of vehicles must be produced in Brazil by July 1960 following the progressive nationalization schedule. It implied that the automobile assemblers would need to make parts in-house while outsourcing to local suppliers as much as possible to reduce their investment. If an assembler could produce or purchase locally heavier and more expensive components, it could import lighter and cheaper parts in larger volume with rationed foreign currency; hence, it could make more cars. Thus, Sindipeças, the association of auto-parts makers, had the bargaining power to some degree. Addis (1999) points out that the GEIA's nationalization schedule followed the promise of

Sindipeças in production capacity enlargement. Thus, GEIA's orientation enabled implantation of the automobile industry to advance to the 'point of no return' in just one presidential term.

Investors submitted investment plans, and they obtained subsidized credit and differentiated exchange rates during the construction of the factory. There was bargaining between such national aims and foreign companies' profit maximization. Shapiro (1994) argues that GEIA has sufficient authority and coherence to make the government commitment credible to responsible foreign firms on the one hand, and to make it costly for firms playing rent-seeking. By offering reasonable distribution of rent in the closed market, which stimulated oligopolistic competition, the government was able to kickstart local automobile production with perhaps a more significant number of firms and size of investment considering the size of the Brazilian market than if it were in a plain competition.

By accommodating the proposal of two different perspectives, the Plan of Targets became too ambitious, without an order of preference and structure of inter-relations, and lacked coherence. It was nonetheless viable because of generous support from the U.S. government, whose Pan-American initiative[6] to prevent communism from gaining power after the Cuban Revolution. It left an excessive amount of foreign debt and dependence on external finance later on.

The government expenditure expansion following the implementation of the Plan of Targets resulted in rising fiscal deficit and inflation. The economic crisis that preceded the military coup in 1964 demanded strict macroeconomic adjustment in 1964-67 through contraction of public spending and money supply, slashed salaries, high public-service tariffs, elimination of subsidies, centralization of tax collection, and an incentive to the capital market, exports, and foreign direct investment inflows.

4.3. The Military in Action: First National Development Plan, 1972-74

Under the military regime, Antonio Delfim Neto was nominated as a finance minister in 1967. He stayed in that position until 1974. Inheriting

[6] It later formalized as 'The Alliance for Progress' in the Kennedy Administration.

the stabilized macroeconomy, he issued the Strategic Plan of Development (PED 1968-70) and pro-business policy program including monetary expansion to reduce the interest rate, reduction of public service tariffs, and introduction of the crawling-peg exchange rate, all while maintaining a fixed minimum wage. PED restricted the role of the government to restore the financial capability for the provision of infrastructure and essential materials to the private sector and did not pretend to expand the areas of productive activity.

For Delfim Neto, the industrial policy is applicable only to correct a market failure. He also considered a government failure to be more problematic than a market failure. He approved the role of the government in developing infrastructure and essential material industry. Still, he denied government interventions for the diversification of an industrial base during the period of Geisel administration.[7] He famously claimed the 'theory of a cake,' which argued that he must make a cake bigger before he would divide it. Tavares et al. (2010) point out that the official document of PED was the first to recognized BNDE as the leading institution of development policy. Especially, FINAME (Fund for the Finance for the Acquisition of Machines and Industrial Equipment) became an important financial instrument for the promotion of the capital good industry providing suppliers' credit and buyers' credit in the acquisition of domestically produced capital goods.

During his period, most of the large infrastructure projects financed by BNDE were carried out by state-owned enterprises (SOEs). BNDE also invested in steel mills as their minority shareholder, as if it were a giant holding company in the sector financing 70 to 80 per cent of all capital investment in the steel industry in the 1960s. At the same time, the BNDE expanded the finance to the private sector, occupying about 70 per cent of the total financing of BNDE by 1970 (Musacchio and Lazzarini 2014). PED was followed by the Program of Goals and Basis for the Governmental Action (MBAG 1970-73).

Successful macroeconomic stabilization was followed by high economic growth in 1968-73, nicknamed as an economic miracle. At that stage, the

[7] These assertions are based on the text of Delfim Neto's interview in a TV Câmara program (December 3, 2003) in the arquive *Memória Política*. https://www2.camara.leg.br/a-camara/documentos-e-esquisa/arquivo/depoimentos/Memoria%20Politica/Depoimentos/delfim_netto/texto.html.

military government launched its first development plan: I Plano National de Desenvolvimento (I National Development Plan) – I PND (1972-1974). I PND focused on the construction of transportation, telecommunications, and energy infrastructure. Among others, North-South and East-West integration road construction, such as Transamazônica Road and Cuiabá-Santarém Road, are most notable. The land in the newly connected inland and Amazônia was redistributed to small farmers as a part of the land reform program (PROTERRA). It also included a large-scale Itaipú binational hydroelectric power generation project with Paraguay. The government also created state-owned enterprises for naval construction, steel, and petrochemical industries. Introducing the Program for the Promotion of Large National Enterprises (Programa de Promoção de Grandes Empreendimentos Nacionais), I PND induced Brazilian enterprises to participate in strategic sectors and paved the way to the triple alliance scheme of state, private, and foreign capitals in industrial development.

4.4. The Forced March Toward a Crisis, 1974-79

4.4.1. Second National Development Plan

The international economic condition deteriorated after the first oil crisis in 1973. While developed countries turned to macroeconomic adjustment to contain inflation, the Brazilian government chose a continuation of growth with indebtedness. Castro (2004) described this decision as a *forced march* (*marcha forçada*). External borrowing was very cheap because of the abundant supply of loans recycling petro-dollars. There was optimism in Brazilian government judgment that the crisis was transitory, and the global economy will recover very soon.

Thus, the Second National Development Plan (II PND) was launched in 1974. It aimed at increasing the domestic supply of essential industrial input and reducing the dependence on imports to reform the balance-of-payment structure. In the socio-political sphere, the government sought further regional integration and poverty reduction. The II PND was formulated by IPEA (Institute of Applied Economic Research) under the authorization of João Paulo dos Reis Velloso, then the Minister of Planning. The II PND was critical to Delfim Neto's 'theory of a cake,' arguing that economic growth itself cannot solve the problem of income distribution. The II PND also claimed that government control would overshadow individual decisions, and foreign capital was not an exception (D'Araujo

et al. 2005).

In terms of sectors, II PND placed focus on essential industrial materials (steel, non-ferrous metal, petrochemical products, fertilizer, pesticide, paper and pulp, materials for the pharmaceutical industry, nonmetal minerals, products such as cement and sulphur), capital goods, food, and energy. Support for the steel industry accounted for 20 per cent and petrochemical for 11 per cent on average of BNDE loan approvals in the 1970s (BNDES 2018). State-owned companies undertook the central part of an investment in essential industrial materials. In other sectors, private companies accounted for a large part of the investment with massive support by BNDE.

To meet the objective of expanding the funding capacity of BNDE, the fund from the Social Integration Program (PIS) in the private sector and Program of Asset Formation for Public Servants (PASEP) was started to be administered by BNDE in 1974. These programs were introduced in 1970 as social contributions payable by employers to finance the funds for insurance for unemployment, child benefits, and allowance for low paid workers. PIS/PASEP became a prominent source of funding for II PND.[8] There were some programs of II PND which were linked to specific purposes. With the general aim of reducing the dependence on imports, the military regime at that time was particularly concerned with fuel and informatic devices as areas of strategic interest for economic and technological national security.

4.4.2. National Alcohol Fuel Program (Pro-Álcool)

The most serious problem in the balance of payments amid the oil crisis in 1973 was the hike in the price of imported fuel. The Brazilian government implemented the import substitution of petroleum with ethanol made from abundant locally grown sugar cane. This policy was formally launched in 1975 as the National Alcohol Fuel Program (Pro-Álcool). The technology was already available. The government set the objective of replacing 12 per cent of gasoline consumption for anhydrous ethanol. Sugarcane plantation owners and ethanol distilleries received a subsidy. In the

[8] The constitution of 1988 provided that a part of Workers Protection Fund (Fundo de Amparo ao Trabalahdor, FAT) would be invested in development projects of BNDES, which bears the long-term interest rate (TJLP) earning obligation.

beginning, sugar cane production was concentrated in the Northeastern region. Because there was a severe problem of poverty there, Pro-Álcool at the same time aimed at poverty reduction by increasing employment in the sucro-alcohol sector.

In the first half of the 1980s, the goal of the replacement rate was raised to 23 per cent. The production of ethanol was scaled-up with subsidized loans. Large scale sugar cane plantations and distillers were established in the Southeastern region where agricultural productivity is higher than the Northeastern region. The state organ Aeronautic Technology Center led the development of a fully ethanol-fueled engine (EFE). The government reduced the industrial products tax (IPI) for the sales of EFE cars based on the agreement with the National Auto vehicles Manufactures Association (ANFAVEA).

However, a further upscale of Pro-Álcool was frozen in the late 1980s. With the fall of petroleum prices in the international market, Brazilian ethanol lost competitiveness, and it became impossible to maintain the fuel subsidy. The Fernando Collor de Mello Administration extinguished Pro-Álcool 1990.

There was a resurgence of ethanol in the 2000s. German manufacture Bosch invented injection system technology for a flex-fuel engine, which can operate with the electronic control unit any mixture ratio of gasoline and ethanol. Because of the end of the Informatic Law, which restricted imports of electronic devices in the Brazilian market (explained below), it became possible to introduce flex-fuel engine cars in the Brazilian market. In the 2000s, the increase in the price of petroleum made Brazilian ethanol competitive. Brazil's adherence to the global agreement on the reduction of greenhouse gas emission also pushed automakers to produce flex-fuel cars.

Despite favorable conditions in terms of the availability of land and climatic conditions suitable for sugar cane production, the competitiveness of Brazilian ethanol is not sufficiently strong in the international market. According to analysis by the International Energy Agency (IEA 2019), the ethanol production cost is higher in Brazil than in the United States. The pressure for cost reduction is weak because the price of gasoline and diesel is higher in Brazil, and ethanol is still competitive in the Brazilian domestic market. Ethanol prices are coupled with the international price

of sugar because most of the ethanol distillers also produce sugar, and they determine the proportion of these two products to maximize their profit. Such instability also reduces competitiveness.

4.4.3. Informatics and microelectronics sector program

Unlike GEIA's policy for the automobile industry, the policy for the informatics and microelectronics sector prohibited foreign firms' ownership. The government introduced measures to promote domestic companies in the new market, which had not been occupied by multinational firms, and obtain technological autonomy in that area (Tigre 1995). In 1977, an agency in the Ministry of Planning, CAPRE, outlined a policy to select locally-owned manufacturers to produce mini-computers, with initial one-time-only technology licensing from minor foreign firms leading to subsequent development of their own technology. The intention was to obtain 'technological autonomy' in electronics technology, which was predicted to bring revolutionary change. National Informatics Policy (Lei 7.232/1984.10.29) guaranteed the market reserve for Brazilian firms in the computer industry, and Special Secretary of Informatics (SEI) obliged them to pay higher prices for purchasing domestically produced parts and components for eight years to fill the 'technological gap.' Evans and Tigre (1989) wrote that the domestic market of computers was split among a large number of small companies and thus plagued by very high production costs. Companies in Manaus Free Zone in the State of Amazonas received incentives.

It soon became apparent that users were not satisfied by the widening gap between the international and national technological levels, as shown by the large number of smuggled microcomputers.[9] The Brazilian market lacked scale economies for competitive domestic production with high local content. The restriction of imports was supported not only for technological nationalism but also because of the severe balance of payments constraint since the second oil crisis. There was no systematic government support for technological development due to the fiscal crisis.

Market reserves and import restrictions on informatics came to an end during the process of trade liberalization in the 1990s. After the market

[9] According to Tigre (1995), 70 per cent of microcomputers in the Brazilian market in the period of the market reserve were illegally imported.

liberalization, most manufacturers established in the atmosphere of the market reserve turned out to be importers (Tigre 1995). Still, support was given to technology development. The reformed Lei de Informática (Lei n.º 8.387, 1991/12/30) introduced the basic productive process (PPB) specified by the notice of Ministry of Industry, Trade, and Service (MDIC) with which companies must comply to be considered as domestic production and receive a benefit. The bylaws in 1993 (Decreto n.º 792, 1993/4/2) obligated companies receiving benefits to spend at least 5 per cent of their sales on R&D. Restrictions on eligibility for benefits were relaxed later. It eliminated restrictions on multinational companies and encouraged R&D of private companies in Brazil through tax incentives. Companies outside the Manus Free Zone were also eligible to receive the fiscal stimulus (15 per cent of Industrial Products Tax).

The unfortunate case of the electronics and informatics industry illustrates an ineffective industrial policy where the government just provided companies with protected local markets but did not extend support to basic research or human resource development. It also restricted the introduction of foreign technologies, which might have facilitated capacity building and indigenous technological development. It seems that this failure inflicted a loss on Brazil of missing the third industrial revolution in digital technology (see Section 2). This had a lasting effect on the competitiveness of Brazilian industry.

4.5. Projects in which knowledge creation support had an essential role

4.5.1. The transformation of infertile savanna to rich granary – Cerrado Development Program (POLOCENTRO/PRODECER)

The vast land in the central plateau is occupied by the Cerrado biome, characterized by acidic soil and a tropical savanna climate. Most of the Cerrado was not utilized for agricultural production because it is considered not suitable for farming. POLOCENTRO (1975-1979) outlined the placement of farming settlement along with a trunk-road network. It became the significant regional action of II PND. The idea was to expand the domestic food supply to attend growing demand in urban areas under the industrialization strategy. However, the POLOCENTRO settlements were too remote from large cities, and agricultural productivity was low without an adequate technical support. They ended as self-subsistent villages.

POLOCENTRO was followed by the Japan-Brazil Agricultural Development Cooperation Program (PRODECER 1979-2001). PRODECER was a combination of the key scientific research by EMBRAPA (Brazilian Agricultural Research Corporation) to adapt the soybean to a tropical climate, financial assistance to farmers, and rural extension services for technical assistance by CAMPO (Companhia de Promoção Agrícola). The Japanese government supported the project through technological cooperation (JICA) and financial cooperation (OECF) for the agricultural credit for a large scale mechanized farming. The initial phases of PRODECER partly depended on the transport infrastructure left by POLOCENTRO.

Institutional organization of the Cerrado agriculture encompasses various key units such as Embrapa, CAMPO, state banks, JICA, agricultural cooperatives, and IBAMA (environmental regulation agency). Federal and state governments played the role of articulating these units with guiding policies and programs as well as coordination. Endowed with vast but infertile land, the agricultural potential of the Cerrado would remain dormant until workers, capital, and technology were deployed through the combined effects (Hosono et al. 2019).

4.5.2. The birth of aeronautic industry in the tropics – Embraer

Since the Vargas administration created the Ministry of Aeronautic in 1941, it became a national interest to foster domestic aeronautic technology to strengthen the security system. This was followed by the foundation of the Organization Committee for Technical Center of Aeronautics (COCTA) in 1946 for scientific research and the Technological Institute of Aeronautics (ITA) in 1950 to promote the university-level education of engineers. The supply of human resources from these research and education institutions was essential for the inauguration of Embraer (Brazilian Aeronautics Company) as a state-owned enterprise (SOE) in 1969. They are all located in São José dos Campos (State of São Paulo).

Embraer soon stated its intention to supply aircraft to the civilian commercial passenger and agricultural markets, as well as to military defense. The government supported Embraer with the defense aircraft acquisition program and technological alliance with the Italian aviation industry (Aeritalia and Aermacchi). This process gave Embraer a unique opportunity to absorb technology and to improve its workforce qualification in cutting-edge knowledge (Francelino et al. 2019).

Yet, Suzigan and Furtado (2006, 176) remind us that, 'Until the late 1980s and the early 1990s, Embraer was still considered by many to be a venture between absurd failure and very costly success. For some, it was another one of these "artificial jabuticabas" that Brazil insists on doing, contradicting vocations and wasting opportunities' (original in Portuguese, my translation). The financial crisis in the early 1990s led to privatization in 1994. Goldstein (2002) argues that privatization in 1994 caused a substantial change in the company, allowing new management to introduce new forms of organizing design, production, financing, and marketing and drastically reduce time-to-market. She noted that Embraer's technological capability in product development and the capacity to use alliances to bring new resources into the firm from external sources are constant in the history of the company.

Today Embraer is a leading global company in the regional jet market, competing with a Canadian Bombardier.

4.5.3. Deepwater petroleum exploration of Petrobras

The relation between Petrobras and the Federal University of Rio de Janeiro (UFRJ) is another high-impact example of science and industry alliance in Brazil. Petrobras created its R&D center (Cenpes) in 1963. Cenpes promoted international research cooperation. It also sponsored a partnership with domestic universities for research and education, among which the collaboration with the UFRJ's Graduate School and Research Center in Engineering (Coppe) has become the most important. Cenpes and Coppe are located together in the Fundão campus of UFRJ.

Since the 1980s, offshore crude petroleum exploration of Petrobras advanced farther from the coast into deeper water, and Petrobras has become the world leader in technologies for deepwater oil exploitation. Since the first technical cooperation agreement was signed between the two institutions Coppe and Petrobras, the alliance became enduring. They contributed to developing technologies for the construction of floating platforms, new materials used for equipment, monitoring, computational and simulation technology, mobilizing a comprehensive and multidisciplinary knowledge resource of Coppe in mechanical, electronic, chemical, and metallic engineering, civil and naval engineering, and oceanographic science.

The most outstanding achievement was the discovery of the ultradeep water oil field in the pre-salt layer in 2006. Commercial production started in 2010. According to Petrobras (2020), 1.277 million barrels per day of crude oil were produced from the pre-salt layer in 2019. This represents 59 per cent of the total crude oil production in Brazil that year. The total crude oil production in Brazil increased from 2.054 million barrels per day in 2010 to 2.784 million barrels per day in 2019 (+36 per cent).

4.6. After the Crisis – Reorientation of industrial policy in the 1980s and 1990s

4.6.1. Industrial policy in the 1980s

Brazil returned to a civilian government regime in March 1985. Since then, Brazil went through a steady transition to democracy, but its economy fell into turmoil resulting from accelerating inflation in the second half of the 1980s. Faced with financial constraints, the past government activism in development was obscured. Industrial policy in the 1980s was redesigned, emphasizing consolidating the basis for building technological capacity and competitiveness. There was some progress by executing the Scientific and Technological Development Support Program (Programa de Apoio ao Desenvolvimento Científico e Tecnológico, PADCT), which was created in 1984, and its Subprogram of Basic Industrial Technology Program (Programa Tecnologia Industrial Básica, TIB). PADCT received the support of the World Bank to compensate for the lack of public funds for science and technology. It enabled a renewal of primary public research laboratories including those which belong to INMETRO (National Institute of Metrology, Quality, and Technology), which concerns basic metrological standards. PADCT-TIB also created the Brazilian Calibration Network (Rede Brasileira de Calibração, RBC), which gathers local secondary laboratories authorized by INMETRO that provide services to private companies.

Another major project under PADCT was the comprehensive review of the competitiveness of the Brazilian industry (ECIB study) led by the University of Campinas and Federal University of Rio de Janeiro (Coutinho and Ferraz 1994). The study analyzed sectoral level competitiveness through the identification of 'sectoral factors' (market structure, industrial configuration, and pattern of competition). They receive the influence of 'firm-intrinsic factors' characterized by strategy and management, innovative capability, productive capability, and human resource, under

the domain of 'systemic factors' such as macroeconomic, international, social, technological, infrastructure, fiscal and financial, and politico-institutional.

We can also point out that government was looking for the role of a coordinator in the bottom-up approach in modernizing industries by the introduction of the Sectoral Chambers (Camaras Setoriais – C.S.) institutionalized by the Decree 96056 of 1988. C.S. is the assembly of the leaders of business, workers, and government to analyze competitiveness and identify problems and strategies. Despite the original objectives, C.S. was used as a mechanism for price control under high inflation.

4.6.2. Industrial policy in the 1990s

Amid the economic crisis, Fernando Collor de Mello administration (1990-92) introduced a new industrial policy, i.e., Industrial and Foreign Trade Policy (Política Industrial e de Comércio Exterior – PICE) in June 1990. It aimed at adequating Brazilian firms to the international standard quality of products and services. It included a bold reform in trade policy. The average import tariff rate was cut down from 32.2 per cent in 1990 to 16.5 per cent in 1993, together with a significant reduction of non-tariff barriers. PICE identified the role of government in industrial development as guaranteeing macroeconomic stability and restoring a favorable investment environment, preventing the government from absorbing domestic saving and reducing the participation of the public sector.

Under the PICE, the government launched the Brazilian Program of Quality and Productivity (Programa Brasileiro da Qualidade e Produtividade, PBQP). Bonelli et al. (1997) evaluate that PBQP was reasonably successful in enhancing firms' awareness and motivation for quality and productivity. They also contributed to the development and diffusion of a modern method of business administration and capacity building of human resources because PBQP anticipated the necessities of firms to prepare for more open international competition.

PBQP helped foster the human resources of technical and quality management personnel. Inspired by Japan's development success in the post-WWII period, the method of total quality control (TQC) was introduced by Christiano Ottoni Foundation linked to the School

of Engineering of the Federal University of Minas Gerais, under the collaboration with the Union of Japanese Scientists and Engineers (JUSE). It is also worth mentioning that under PBQP, Brazil adopted the international standard of quality assurance management (ISO9000s) and established the National Prize of Quality (Prêmio Nacional da Qualidade).

As a part of the PBQP, the Brazilian government requested technical cooperation from Japan on the project to establish the Brazilian Institute of Quality and Productivity (Istituto Brasileiro de Qualidade e Produtividade, IBQP). The Japan International Cooperation Agency supported the project from 1995 to 2000. This project was designed as trilateral cooperation involving third countries other than Japan and Brazil, such as other Latin American and Portuguese-speaking African countries, whose technicians can also receive training on quality control with the Brazilian peers. The location was in Curitiba of Paraná State. Japan Productivity Center supported this project. While IBQP is a private non-profit organization, in 2002, the government granted IBQP civil organization's status for a public interest, which enable it to sign a partnership agreement with public institutions and jointly develop specific projects.

Another component of PICE was Program of Industrial Competitiveness (Programa de Competitividade Industrial – PCI). It contained programs for sectors involved in the generation of technology, including informatics, fine chemical, biotechnology, precision machine, and new materials.

The PICE also supported the improvement of productivity and quality using a sector-wide approach. C.S. became a forum for the discussion on structural issues. In March 1992, the first tripartite agreement was signed in the automobile sector by associations of assemblers, parts suppliers, and car dealers, workers unions, and government. The deal included: reducing the retail price of cars; reducing value-added taxes; limiting the profit margin of assemblers, suppliers, and sales; expanding car loans for consumers at a lower cost by reducing financial operation taxes; offering tax incentives for exports; maintaining employment, increasing base salaries, and introducing inflation-adjustment mechanisms in salaries. The agreement among the automobile sector also discussed the projection of the yearly production and the of investment. By the end of 1992, there were 20 C.S. and 135 specific working groups (Anderson 1999). This success was short-lived. Instead of reciprocal concessions and engagement, C.S. became the place to manifest the self-interest of each

party and culminated in a dead-end. To avoid the aggravation of conflicts, C.S. was deactivated in 1995.

However, the effective functioning of C.S. in the automobile sector was an exception. As a result of the discussion of C.S. of the automobile industry, the Automotive Regime was established as a sector-specific industrial policy in the MERCOSUR's intra-regional trade scheme. In June 1995, the government conceded benefits to automotive companies that already existed in Brazil and those that had concrete investment plans. They could import from MERCOSUR (mostly Argentina) with tariff exemptions on assembled automobiles to commercialize in the Brazilian market, and parts and components to be used in the domestic production, provided under the condition that they export the required value to compensate for the import.

PICE was also linked to the de-statization[10] program of the Collor administration. It sold the ownership of state-owned companies in industrial sectors as mining (CVRD), aircraft (Embraer), steel (CSN, Usiminas, Cosipa, CST, and others), and petrochemical (Oxiteno, Copesul, and others).

The Fernando Henrique Cardoso administration (1995-2002) issued the New Industrial Policy (Nova Política Industrial) in 1998. The general tone of this policy was that macroeconomic stability, open international trade, and the maintenance of competitive market were fundamental to promote investment, increase productivity, and improve quality. It showed a minimalist posture about government interventions. There were some measures to remedy the high-cost structure in Brazil, such as the interest rate subsidies for export finance (Proex-Equalization) to align the gap of domestic and international interest rates, and the simplified corporate tax scheme for small and medium-size firms (SIMPLES) to reduce the tax burden.

The Cardoso administration furthered de-statization of SOEs in regulated markets such as public utility (electric power generation, transmission, and distribution), transportation (seaport, airport, highway), and banks.

[10] The 'de-statization' was not privatization in a strict sense. Voting shares of some state-owned companies were sold to BNDES and pension funds of state-owned firms. Government was able to influence de-statized companies through these channels.

While transferring these resources from the public to the private sector, the government was concerned about introducing competition to encourage cost reduction and innovation, while regulating prices to defend the public interest. In this regard, the government established Competition Law (1994) and antitrust agency CADE (transformed into an autarchy body in 1994). It also found market regulatory authorities in each sector: ANEEL (electric power), ANATEL (telecommunication), ANA (water), ANTT (road and rail transportation), and ANTAQ (water transportation).

In sum, the bold continuation of import-substitution industrialization to sustain growth after the first oil crisis in 1973, described as 'forced march (*marcha forçada*)' (Castro 2004), was overthrown as a result of the balance of payment crisis and severe government budget constraint in the early 1980s. Therefore, industrial policy in the traditional sense was not in the policy agenda in the 1980s and 1990s. Still, the government enacted a new policy framework to influence industry aligning with the radical policy adjustment through market liberalization and privatization. To improve the competitiveness of firms, support was given to investment in modernizing equipment and R&D. Without having an explicit sectoral target in resource allocation, the government mobilized sectoral chambers to tailor the design of support programs.

5. Contemporary Industrial Policy

5.1. The renaissance of industrial policy

In the 2000s, industrial policy returned to the public debate under the administration of President Luis Inácio Lula da Silva, evolving from the Technological and Foreign Trade Policy (PITCE) from 2004 to 2007, the Productive Development Policy (PDP) from 2008 to 2010, and the Grater Brazil Plan (Plano Brasil Maior – PBM) from 2011 to 2014.

As we reviewed so far, Brazilian industrial policy had tried to meet the developmental challenges. This began with the inauguration of the import substitution industrialization of the steel industry during the Vargas era as the symbol of national sovereignty. The Plan of Targets emphasized the automobile industry to advance the aim of national integration with transportation. During the military regime, the emphasis returned to supplying essential materials such as steel and chemical, while the government also engaged in undertaking ventures in areas of advanced technology such as aircrafts, electronics, and informatics,

obtaining mixed results. Chronic constraints in the balance of payments and the fear of external dependence were a critical concern motivating industrial policies. These policies worked for increasing investment and diversifying the industrial structure. However, they were prone to macroeconomic imbalances. They were also not satisfactory for gaining a genuine competitiveness in terms of product quality and productivity.

After Brazil moved to trade liberalization, competitiveness has become the essential target. Compared to the ISI period of top-down style state developmentalism, industrial policy in the post-ISI period can be characterized by wider acceptance of market-based competition with government's pro-business support based on bottom-up policy formulation. However, these policies could not increase investment rates. Thus, failing to achieve structural transformation in favor of sectors with dynamic growth, the Brazilian economy inclined to deindustrialization.

The Lula administration designed a contemporary industrial policy that embraced these developmental challenges in the past. Industrial policy aims to elevate the level of investment, which must be guided to sectors that would be in sync with the prospect in the global market and justified by Brazil's developmental potential. Such an industrial policy departs from a political agenda of the ruling power. Hence, the formulation of policy is a top-down process, but such a decision is necessarily based on democratic accountability. These elements may characterize the Lula administration as the renewed developmental state. However, as Hochstetler and Montero (2013) claimed, the contemporary industrial policy differs from the previous statism by recognizing the overriding concern of maintaining a macroeconomic balance and robust emphasis on innovation to meet the market-based global competition.

In the following subsections, we will discuss in detail the formulation process of the industrial policy of the Lula administration. We first show the framework of policymaking consisting of political and operational dimensions. Next, we discuss horizontal provisions adapted under the political directives. Then, some sectoral policies are examined.

5.2. Framework of industrial policymaking

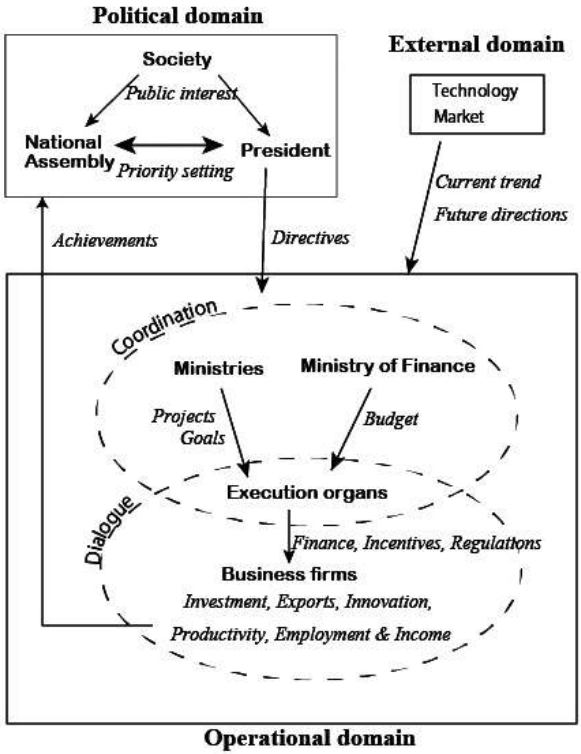
In an interview with the author,[11] a former executive of the National Economic and Social Development Bank (BNDES), João Carlos Ferraz listed the following essential elements for industrial policy:

- The political leadership of the president to give general directives to realize his/her political agenda;
- Sensitivity to the external and political environments;
- Concrete projects and goals that substantiate the directives from the political top;
- Sufficient financial and technical resources in the execution organs;
- Capacity within execution organs to coordinate with governmental institutions;
- Capacity within execution organs to dialogue with the private sector, without being beholden to their interests;
- Realism and pragmatism.

Ferraz and Coutinho (2019) also document similar assertions. Figure 3.8 depicts the logical structure. We can divide the process of the formulation of industrial policy into the political and operational domains. In the political domain, society expresses public interests by votes and through the media to the president and the national assembly. To realize his/her political agenda to meet the expectation, the president sends his directives, in due consideration of policy priorities set in the legislative process, to ministries and execution organs.

Next, the industrial policy formulation comes down to the operational domain. Ministries of specific areas formulate projects and set goals in close alignment with the president's directives. They also consider the external domain consisting of the current trends in technology and markets in the international sphere, as well as their future projections. The executing organ such as BNDES translates these requirements and conditions into concrete policy instruments such as loans, incentives, and regulations. Industrial policies are thus implemented to achieve outcomes in investment, exports, innovation, productivity, employment, and income. Actors in the political domain will assess the relevance of these variables.

[11] João Carlos Ferraz, Interview by the author, Online, July 7th, 2020.



Source: Author's elaboration.

Figure 3.8. Framework of Industrial Policymaking

In these regards, there are several critical capabilities required for the execution organ of industrial policy. The mission of an execution organ is to convert the president's discourse of developmental challenges into concrete policy goals. To achieve this mission, the execution organ must have a high level of analytical capability to disentangle political and international factors.

The execution organ also needs to have the capability to coordinate policies with related ministries, especially with the Ministry of Finance, to obtain the necessary budget. This type of coordination requires a realistic sense of maximizing outcomes within the limitations of the budget, as well as a result-oriented pragmatism cutting through crossing interests.

The dialogue with the private sector requires another type of capability of the execution organ to secure the implementation of investment projects.

It demands a strong internal capacity of execution organs to preserve technical autonomy to serve the public interest, without submitting to private interests. In this regard, Ferraz and Coutinho (2019) comment that BNDES evaluates investment projects on the same legal, technical, and financial criteria as commercial banks such as profitability of the project, the adequacy to environmental impact regulation, and the demonstration of payback capability.

5.3. Directives and measures of industrial policy

Kupfer et al. (2013) explain that the PITCE aimed at strengthening the institutional framework by creating agencies and modernizing legislation to make innovation-inducing instruments more effective. The policy derived from the first industrial policy directives of the Lula administration (Diretrizes de Política Industrial, Tecnológica e de Comércio Exterior). The directives aimed to strengthen institutional articulations for innovation capacity and export capacity within a scale economy. Sectoral focus returned to policy design, above all, technology-intensive sectors, such as capital goods, electronics, pharmaceutical, and software. Firms in new technology sectors such as biotechnology, nanotechnology, and biomass and renewable energy, including start-ups, were also supported. The PITCE intended to promote technological development and international competition, and endeavored to reduce large and growing trade deficits in these sectors.

To compose PITCE institutions, the government established the Brazilian Agency of Industrial Development (ABDI) in 2004 as an implementing organization and National Council of Industrial Development (CNDI) composed by representatives of the private sector and the government in 2005 as a deliberation body. Then, the Law of Goods (Lei do Bem) was put in effect in 2005. It concedes tax exemption or reduction for companies that: (i) engage in software development; (ii) engage in export; (iii) conduct R&D; and (iv) purchase digital data processing equipment. The Law of Technological Innovation in 2005 intended to promote the collaboration between scientific research institutions and businesses through tax reduction. The reformed Informatics Law (2006) provided for companies conducting R&D in ICT to receive the benefit of exemption or reduction of the Industrial Product Tax on purchasing informatics and automation equipment. PITCE also included measures to support small and medium enterprises through the simplification of taxation, tax exemption for the

acquisition of new equipment and the introduction of ICT, provision of subsidized finance for working capital and investment, and technical assistance to industrial clusters. BNDES and FINEP (Funding Authority for Studies and Projects) established credit lines to support investment.

The government revised its industrial policy and announced PDP. The PDP was designed to sustain the expansionary cycle of the economy with the aims of increasing supply capacity; maintaining the robustness of the balance of payments, to strengthen the innovative capacity; and fostering small and medium enterprises (SMEs). The corresponding specific targets by 2010 were to increase investment/GDP share from 17.6 per cent in 2007 to 21 per cent; increase Brazil's share in the world export from 1.18 per cent in 2007 to 1.25 per cent (in other words, from 169.6 billion US dollars to 208.8 billion US dollars); elevate the research and development expenditure share in GDP from 0.51 per cent in 2006 to 0.65 per cent (in other words, from 11.9 billion BZ reais to 18.2 billion BZ reais); and increase by 10 per cent exporting SMEs from 11,792 in 2006 to 12,972.

In PDP, the sectoral target of PITCE was greatly broadened to include agroindustry, textile and clothing, leather and shoes, toiletry and perfume, wooden products and furniture, and automobiles. In the face of the international financial crisis in 2008, a new law was enacted, establishing additionally Program to Sustain Investment (PSI), by which BNDES financed acquisitions of capital goods at a subsidized financial cost below the treasury bill rate (SELIC). Kupfer et al. (2013) explain that PDP had an anti-cyclical role that proved crucial in the federal government's efforts to combat the effect of the crisis and sustain economic growth.

In 2011, President Dilma Rousseff succeeded President Lula, who ended his two terms with high popularity and an economic euphoria with high GDP growth and substantial poverty reduction. Her administration saw, however, the end of the commodity boom, which boosted the Brazilian economy during the predecessor's period, and the government account problem, which required a significant adjustment. The industrial policy of the first-term Dilma administration, PBM, redefined its directives in five elements: (i) to provide support for domestic production of sectors facing fierce competitions with imports; (ii) to expand and create new technological competence; (iii) to develop energy supply chains; (iv) to diversify exports and to internationalize firms; (v) to promote manufacturing products of intermediate technological level with the

consolidation of a natural knowledge economy. Concrete measures corresponding to each directive were: (i) the government procurement preference for domestic products (construction machines, vehicles, agricultural equipment, school uniforms, etc.) and some measures for specific sectors; (ii) the continued provision of investment finance with PSI/BNDES and FINEP; (iii) the continued support to the petroleum and gas sector; (iv) the continued support to exporting firms with the reduction of taxes on the purchase of capital goods and corporate income tax; (v) the reduction of social security contributions levied on wage payments in labor-intensive sectors (garment, shoes and leather products, furniture, and software), thus reducing labor cost while increasing taxes charged on sales. Among the sector-specific measures, the policy for the automobile sector (Inovar-Auto) became highly controversial. Automobile companies received special benefits of reduced industrial product tax if they were to make a new investment, increase employment, engage in local procurement, and increase R&D. Japan and the European Union alleged to WTO that the policy was discriminatory. The Appellate Body upheld this appeal and recommended Brazil bring this policy into conformity with the WTO rules. The context of the PBM was marked by the international crisis and fierce competition with imports. Kupfer et al. (2013) explain that PBM tended more and more toward defending the internal market and recovering the systemic conditions for competitiveness.

5.4. Sectoral approaches subject to the directives

We find a basic concept of sectors in industrial policies in the Lula administration period in Ferraz et al. (1995), which is based on ECIB Study (Coutinho and Ferraz 1994). Ferraz et al. (1995) described competitiveness as dependent on a firm's capability, which, in turn, evolves concurrently with the firm's strategy. The firm's capability consists of four elements: innovation (technology), management, human resources, and productive structure. The nature and patterns of evolution of competitiveness thus defined exhibit significant sector-specific idiosyncrasies. Such peculiarity arises from the characteristics of the market (size, level of sophistication, and access to international markets); sector configuration (natural advantage of a country, ownership and competitive structure, inter-firm network); and regulatory/institutional regime (legal framework, macroeconomic policy, trade policy, the role of the State). Understanding of the sector-specific idiosyncrasies is essential to formulate the sectoral measures in industrial policies.

In this perspective, Ferraz et al. (1995) show four broad patterns of industrial groups:

- Commodity group: Firms produce homogeneous products in huge quantities, the prices of which are determined in the international market. They compete in the oligopolistic international market. Scale economy is necessary for cost reduction and to consolidate the competitiveness position in the global market.
- Durable goods group: This group is comprised of assembling-type manufacturers that make use of advanced technology and place great importance on scale economies, including final producers and parts and components suppliers. The market structure is oligopolistic and competition includes product differentiation in various attributes (price, brand, technology, user assistance, and after-sales services). Besides requiring a scale of production, firms compete in assembler-supplier integration, new product development, worker training for a flexible production system, etc.
- Traditional goods group: This group consists of firms that produce low-technology consumer products, supplying them to a market segmented by income level of consumers. Some companies compete in the higher-end market, which shows lower elasticity of price and higher sensitivity to design and other non-monetary attributes of a product. Others operate in the lower-end market, which requires less technological content. In both cases, firms must deal with high fluctuation in terms of seasonality and market demand conditions. Hence, maintaining flexibility in production scale is essential. Activities to support original product differentiation is less important in this group. Instead, the capacity to learn from others (new technology from the diffuser group and other firms within the sector) matters a lot. For this reason, industrial clusters are often organized at a regional scale.
- The diffuser of technological progress group: This group contains capital goods and essential materials (electronic and chemical). Firms compete in the oligopolistic market with high product differentiation. To gain a competitive edge, this group invests more in its R&D. Firms also maintain closer relationships with academic institutions. The capacity for innovation is the main entry barrier for newcomers.

We can interpret the design of industrial policies in the PT (i.e. Lula-Rousseff) administration era in these concepts. It should not be confused

that the government and execution organs freely picked up winners and provided policy instruments in favor of beneficiaries. As depicted in Figure 3.8, the directives from the political domain set the tone, and the choice of measures in the operational domain is subject to the directives. For example, if the policy directive was to expand exports to stabilize the balance of payments, it was natural to promote the above-mentioned commodity group given the favorable international market conditions and the natural competitive advantage that Brazil possesses. As previously discussed, companies in this sector boost competitiveness by increasing the global share through mergers and acquisitions at the worldwide scale, vertically integrating commodity production and logistic business, and diversifying their commodity portfolios. The scale-up of commodity firms called the 'national champion policy' has an economic rationale based on the competitive strategy of this group, which requires a scale economy.

In the same vein, if the policy directives point to enhancing innovation, the operational domain turns to the above-mentioned diffuser group. Support for R&D was directed to capital goods, electronics, pharmaceutical, and software in the PITCE because they were the diffuser group, whose competitiveness depends on the capacity of innovation. If the directive emphasizes employment, more attention will be given to the traditional good sectors whose products are less differentiated. PBM focused on reducing Brazil's costs is essential to competing imports. It was also necessary to note PITCE included support for industrial clusters.

However, there were discrepancies between the original concept and actual industrial policies during the PT administration. Because of political pressure from other sectors and the need for dealing with the effect of the 2008 international financial crisis, PDP and PBM broadened beneficiaries to the durable goods group and traditional good group. By supporting technological development for almost all sectors, the policy's attention to the peculiarity by sectors based on different nature of competitiveness became ambiguous. As a result, despite the promotion of R&D by industrial policies, resource allocation to technology-intensive diffuser groups decreased, and innovative activities within the Brazilian industry as a whole stagnated. Policies to promote knowledge creation, human development, and learning were not relevant in industrial policies under the PT administration.

Related to the shortfall in innovation, we can point out a lack of

comprehensive sector-wide programs for knowledge creation, human development, and learning. Related to this, we can point out that export expansion in the PT era partly resulted from previous sector-specific programs explained in Sec. 4.5. The case of soybeans is a notable example. The agricultural development of the Cerrado crucially depended on the initial intervention to emphasize sector-specific knowledge and to build institutions for scientific research and technical transfer. Embraer's success in aircraft exports and the discovery of Pre-Sal (deep underwater) crude oil field by Petrobras can be explained in the same way.

5.5. The role of BNDES as a critical execution organ

The private bank sector in Brazil shows a high degree of concentration: five-bank asset concentration ratio rose to 85.0 per cent in 2016 from 48.7 per cent in 2001 (data from World Bank DataBank, Global Financial Development). Private bank loans are not only scarce and volatile in terms of volume, but they are also high-cost,[12] and their loans are strongly skewed to the short maturity segment (Torres and Zeidan 2014).

Hence, BNDES, as a public development bank, is expected to mitigate malfunctions of the private market and to play a significant role in the provision of long-term credit. These resources were used to expand production capacities, acquisitions of smaller businesses in the same segments, and mergers of rival companies both within Brazil and overseas. According to Ferraz and Coutinho (2019), the BNDES has the following functions: on-lending operation (i.e., commercial banks access BNDES funds and extend credit to their client); SME loans guarantee fund; equity investment through BNDESPar (BNDES Participações S/A); and export loans to capital goods exports and overseas engineering services. BNDES's role is to formulate, operationalize, and implement development policies. BNDES has been central to industrial policy formulation with qualified technical staff and technical autonomy.

Ferraz and Coutinho (2019) classify three different roles of development banks: pro-cyclical, counter-cyclical, and pre-cyclical. Although lending by private banks could expand pro-cyclically, the short-termism of Brazilian banks requires BNDES to provide necessary funds for firm growth even

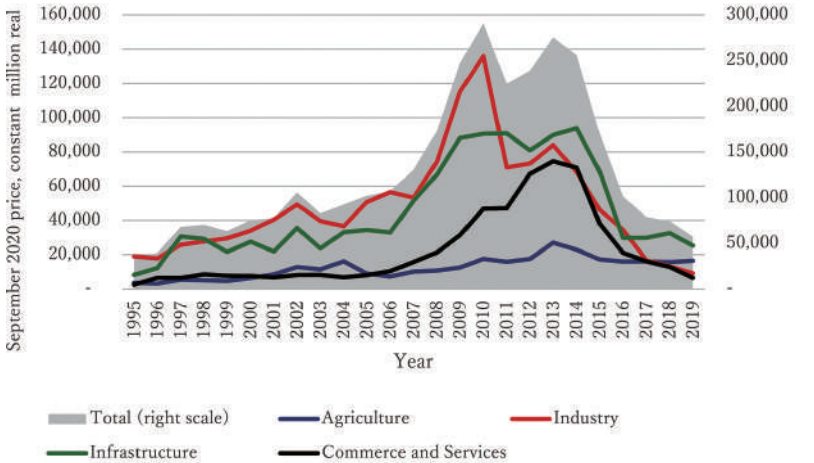
[12] Brazilian private banks' lending-deposit spread has been maintained around 40 per cent in the last two decades.

during the upswing in an economic cycle. The counter-cyclical role of a development bank may not be to overstrain itself to offer loans under repressed demand for investment coupled with credit restrictions. BNDES provided working capital and renegotiated terms of credit to keep businesses afloat. The pre-cyclical role is related to technical support for investment ahead of the upswing cycle through feasibility analysis and financial evaluation of investment projects.

Figure 3.9 depicts the amount of the loan disbursement by BNDES in last 25 years. The remarkable expansion of BNDES finance during the PT administration period is noticeable. During the Lula administration period (2003-10), loans to the industrial sector increased most significantly; in particular the food and drink, chemical products, and transportation equipment sectors received two-third of the loans directed to the industrial sector. The former two sectors undertook several mergers of big companies to challenge global competition. The transportation equipment sector is important for exports (aircraft and automobile), and also for employment generation through domestic production linkage (automobile). Later, loans to the commerce and service sector grew the most. Of notable importance was the civil construction sector under the My House My Life Program (Programa Minha Casa Minha Vida), the flagship low-income class housing project of the Dilma Rousseff administration (2011-August 2016). Financing to the infrastructure sector also maintained a high level during the PT administration period.

BNDES finance dropped sharply after the impeachment of President Rousseff. The conservative force that took power reconsidered the enlarged position of BNDES problematic because it fomented inflationary pressure on the demand side and also for other reasons explained below.

The prominent presence of BNDES received criticism in three respects. First, the expanded BNDES loans have an impact on public finance because of the negative interest rate margin between SELIC (monetary policy instrument rate) and TJLIP (long-term interest rate). Treasury pays the former to issue bonds, and BNDES pays the latter for the loans from the Treasury. Admitting the immediate impact, as Ferraz and Coutinho (2019) argue, we should evaluate the impact on fiscal accounts by the total balance of costs and benefits, considering the investment, production, tax payment, and BNDES' dividend payments to the Treasury, which would not be realized if loans had not been made.



Source: Author's elaboration based on Séries setoriais, Estatísticas Operacionais Consolidadas do Sistema BNDES. https://www.bndes.gov.br/wps/portal/site/home/transparencia/centraldedownloads.

Figure 3.9. Disbursement of BNDES Loans by Sectors (1995-2019)

The second criticism argues that BNDES loans do not induce investment. Lazzarini et al. (2014) did not find support for the political view that claims that BNDES bailed out firms with a bad performance for political purposes.[13] However, they found at the same time that BNDES loans did not induce investment, nor did their loan projects achieve higher productivity. They concluded that low-risk good borrowers are attracted to BNDES loans because of their subsidized-nature, leaving higher-risk borrowers to private banks, causing financial disintermediation. De Souza and Ottaviano (2018) found that BNDES loans helped relax credit constraints that allowed granted firms to match the productivity growth of similar firms that were not credit constrained, although they weren't able to outperform the productivity of the latter. De Oliveira (2019) also found a positive impact on the investments of loaned firms by using the dataset, including more samples from private firms. Maffioli et al. (2017) presented a significant positive effect on granted firms' employment growth and export volume, while no effect was found on wage differential, implying an insignificant impact on productivity.

[13] The Jair Bolsonaro administration tried at any rate to bring a charge of corruption against BNDES's top executives during the PT administration, but the investigation found no indication of irregularity (Valor Economico January 21, 2020).

The third criticism points out that BNDES was used as a political instrument. Generally speaking, a national development bank cannot be independent of the direction shown by the government; it is expected to carry it out faithfully. For BNDES during the Lula administration era, priority areas were innovation, climate change, regional development, competitiveness, infrastructure, and micro-, small-, and medium-sized enterprises. Ferraz and Coutinho (2019) claim that executor agencies like BNDES had technical autonomy, namely a collective capacity to approve or reject projects based exclusively on an explicit project and credit evaluation criteria (technical, legal, economic and financial, permanently scrutinized by the banking supervisory agency). It is widely accepted that BNDES has high competency to examine the eligibility of borrowers on a purely technical basis (Mssacchio and Lazzarini 2014).

According to Torres and Zeidan (2014), BNDES was the most important tool used by the Brazilian government as a counter-cyclical response to the financial crisis. Ferraz and Coutinho (2019) comment that since the mid-2014 onward, BNDES acted counter-cyclically by providing working capital and renegotiating the terms of credit to keep business afloat. By expanding loans, BNDES sometimes contradicted the Central Bank's monetary tightening to control inflation.

Another political view of critics to BNDES is the concentration of loan portfolios to large firms. Previous studies found that firms who donated to the electoral campaign of winning politicians are more likely to receive BNDES loans (Lazzarini et al. 2014). Some relate the political view with a 'national champions policy' by which BNDES took policies to boost-up several firms, like JBS, BRF, Marfrig, and Aurora in meatpacking, Fibria in the paper, Vale in mining, Petrobras in petroleum exploration, Gerdau in steel, Embraer and Marcopolo in transport equipment, and Odebrecht, Camargo Corrêea, and Andrade Gutierrez in construction. BNDES loans were essential for their firms' growth through mergers and acquisitions and establishing overseas operations to become representative firms of Brazil. Criticism of national champions has become acute because the involvement of these companies in major corruption incidences under the PT administration has become public.

5.6. The effects of industrial policy on investment

Because the objective of industrial policy is to induce structural

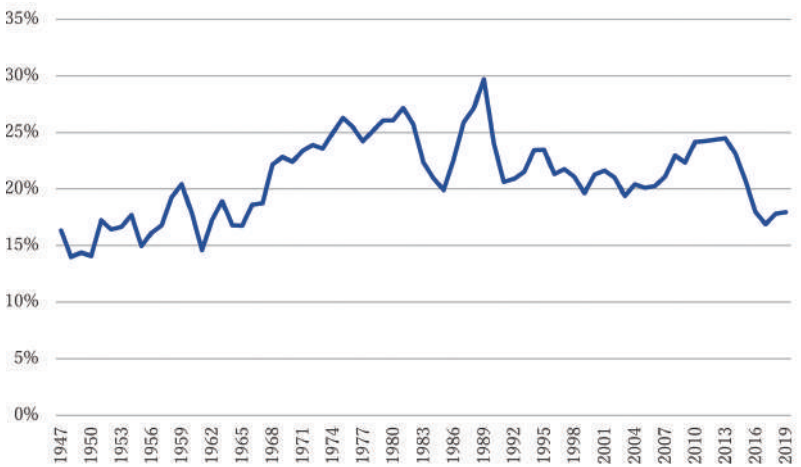
transformation of the economy, we expect its impact in the increase in investment. Figure 3.10 depicts the long-term trend of the share of gross capital formation in GDP. We can see that investment grew significantly from the beginning of the 1960s to the end of the 1970s. We might infer a positive association with active industrial policy which we described in Sec. 4. Note that we should be cautious about claiming a causal relation between them because such causality can be established only by comparison to the counter-factual assuming no industrial policy in the same period. However, the association between investment and industrial policy seems likely because we can also observe such a relationship in the 2000s when industrial policy returned to the economic policy under the PT administration.

On the other hand, Figure 3.10 also shows that investment remained lower during the 1990s when conservative market fundamentalism dominated the policymakers' thinking. It suggests that macroeconomic stability and free competition were not sufficient to induce investment. Putting ideological debate aside, Brazil needs to face development challenges from the standpoint of both realism and pragmatism.

6. Closing Remarks

Brazil has used industrial policies to propel industrialization. They were powerful tools to achieve national goals of economic development. Goals have changed over the years: i.e., import-substitution industrialization to generate employment and reduce the necessity of imports to overcome the balance-of-payments constraint of economic growth; provision of essential goods for national integration by transportation, energy, and telecommunication; and improved technological capability of national industry to win an international competition.

Corresponding to these challenges, industrial policies boosted industrialization. The Brazilian economy made a structural transformation, shifting resources from agriculture to industry. Industrial policies in the past have shown mixed results. The installation of the automobile industry in 1950s was remarkably rapid. We noted successful cases of knowledge-based development projects such as the Cerrado agriculture development in soybeans and university-enterprise collaboration, which had a significant impact on the emergence of the aircraft industry and deepwater exploration of petroleum. On the other hand, the case of the



Source: Author's elaboration based on IPEADATA.

Figure 3.10. Gross Capital Formation as A Percent of GDP (1947-2019)

computer and informatic device industry was a devastating failure.

This study was not able to identify rigorously what went well and what went wrong. This article preliminary concludes that sector-specific knowledge creation, human development, and learning mechanisms are essential elements of successful industrial policies. We could learn that their success did not depend only on the demand boost of emerging economies and subsidy. There were continuing processes of knowledge creation, human capital development, and learning involving firms and product-specific research and education/training institutions long before their results came out. It is doubtful that only general support for science and technology could lead to successful outcomes. A sectoral approach with strategic forecasting will be necessary.

Soybeans, aircraft, and petroleum have become dazzling star items of Brazilian exports since the 2000s. They would never have become so without public interventions in knowledge creation. Soybeans almost did not exist in Brazilian food habits. In the early 1970s, Brazil imported 80 per cent of its fuel consumption from abroad. That is why the 1973 oil crisis made Brazil explore alternative energy such as sugarcane-based ethanol. Embraer was a state-owned enterprise whose main objective was military defense. It almost went bankrupt in the early 1990s. We found

that Embrapa's R&D and the cooperation of university scientists with Embraer and Petrobras were fundamental.

As we learned from the previous studies, industrial policy serves a larger purpose than shifting the allocation of resources to complement the market mechanism. The government is able to lead structural transformation based on its political integrity, strong institutional capability, and the realistic conformity with the macroeconomic balance and opportunities provided by the external environment. The Brazilian model of contemporary industrial policy has these elements. We also noted that Brazil developed sophisticated institutions for industrial policies built on the interactions between political and operational domains.

In this structure, BNDES has been in the central position in the execution of industrial policies. As a representative development bank of Brazil, BNDES has been a protagonist in the provision of long-term loans and risk capitals because Brazilian private financial institutions are locked in short-termism and are risk-averse. Existing studies acknowledge the importance of BNDES to remedy market failure in the financial market and formulate projects to promote a higher level of investment in key sectors that substantiate the directives of the government to expand exports and to internationalize Brazilian firms. Amidst the profound change from the commodity boom to the global financial crisis, BNDES' support for investment had an anti-cyclical role. However, these studies also point out that BNDES has not been successful in promoting productivity growth and innovation. It is not to deny the importance of BNDES. Still, this aspect requires more study on a desirable institutional setting of entrepreneurial public policies, particularly considering the sector-specific idiosyncrasy in determinant variables in competition, strategy, and capacity building.

Reference

Addis, Caren. 1999. *Taking the Wheel: Auto Parts Firms and the Political Economy of Industrialization in Brazil*. Pittsburg: The Pennsylvania State University Press.

Ades, Alberto, and Rafael Di Tella. 1997. "National Champions and Corruption: Some Unpleasant Interventionist Arithmetic." *The Economic Journal* 107(443): 1023-42.

Aiginger, Karl, and Dani Rodrik. 2020. "Rebirth of Industrial Policy and an Agenda for the Twenty-First Century." *Journal of Industry, Competition and Trade* 20: 189-207. https://doi.org/10.1007/s10842-019-00322-3.

Amann, Edmund, and Werner Baer. 2000. "The Illusion of Stability: The Brazilian Economy under Cardoso." *World Development* 28(10): 1805-19.

Anderson, Patricia. 1999. "Sectorial Chambers: Historic and Agreements - 1991/1995." IPEA Working Paper No. 667. Available at SSRN: https://ssrn.com/abstract=193469 or http://dx.doi.org/10.2139/ssrn.193469.

Andreoni, Antonio, Ha-Joon Chang, and Roberto Scazzieri. 2019. "Industrial Policy in Context: Building Blocks for an Integrated and Comparative Political Economy Agenda." *Structural Change and Economic Dynamics* 48: 1-6. https://doi.org/10.1016/j.strueco.2018.11.003.

Baer, Werner, and Issac Kerstenetzky. 1964. "Import substitution and industrialization in Brazil." *American Economic Review* 54(3): 411-25.

Becker, Gary. 1985. "The Best Industrial Policy is None at All." *Business Week*, August 5, 1985: 8.

Bonelli, Regis, Pedro da Motta Veiga, and Aeriana Fernandes de Brito. 1997. *As Políticas Industrial e de Comercio Exterior no Brasil: Rumos e Indefinições*. Texto para Discussão 527, IPEA.

Castilho Marta, Julia F. Torracca, and Fabio N.P. de Freitas. 2019. "The Competitiveness of Brazilian Manufacturing in Both Domestic and International Markets." In *International Integration of the Brazilian Economy*, edited by Elias C. Grivoyannis, 49-75. New York: Palgrave Macmillan.

Castro, Antonio B. 2004. "Ajustamento X transformação: A Economia Brasileira de 1974 a 1984." in *A Economia Brasileira em Marcha Forcada*, edited by Antono B. Castro and F.E. P.de Souza, 11-95. São Paulo: Paz e Terr.

Cimoli, Mario, Giovanni Dosi, and Joseph E. Stiglitz. 2015. "The Rationale

for Industrial and Innovation Policy." *Intereconomics Review of European Economic Policy* 50(3): 126-32.

Coutinho, Luciano, and João Carlos Ferraz, eds. 1994. *Estudo da Competitividade da Indústria Brasileira*. Campinas, SP: Unicamp.

D'Araujo, Maria Celina, Ignez Cordeiro de Farias, and Lucia Hippolito. 2005. *IPEA 40 Anos: Uma Trajetória Voltada para o Desenvolvimento*. Rio de Janeiro: IPEA.

De Oliveira, Fernando N. 2019. "Investment of Firms in Brazil: Do Financial Restrictions, Unexpected Monetary Shocks and BNDES Play Important Roles?" *Revista Brasileira de Economia* 73(2): 235-51.

De Paula Germano Mended. 2017. "Deindustrialization in Brazil?" In *The New Brazilian Economy*, edited by Elias Grivoyannis, 63-85. New York: Palgrave Macmillan.

De Souza, Filipe Lage, and Gianmarco Ottaviano. 2018. "Relaxing Credit Constraints in Emerging Economies: The Impact of Public Loans on the Productivity of Brazilian Manufacturers." *International Economics* 154: 23-47.

Evance, Peter, and Paulo Bastos Tigre. 1989. "Going Beyond Clones in Brazil and Korea: A Comparative Analysis of NIC Strategies in the Computer Industry." *World Development* 17(11): 1751-68.

Ferraz, João Carlos, and Luciano Coutinho. 2019. "Investment Policies, Development Finance, and Economic Transformation: Lessons from BNDES." *Structural Change and Economic Dynamics* 48: 86-102. https://doi.org/10.1016/j.strueco.2017.11.008.

Ferraz, João Carlos, David Kupfer, and Lia Haguenauer. 1995. *Made in Brazil: Desafios Competitivos para a Indústria*. Rio de Janeiro: Campus.

Francelino, Josiane de Araújo, Ligia Maria Soto Urbina, André Tosi Furtado, and Milton de Freitas Chagas Jr. 2019. "How Public Policies Have Shaped the Technological Progress in the Brazilian Aeronautics Industry: Embraer Case." *Science and Public Policy* 46(6): 787-804.

Goldstein, Andrea. 2002 "EMBRAER: From National Champion to a Global Player." *CEPAL Review* 77: 97-115.

Harrison, Ann, and Andrés Rodríguez-Clare. 2010. "Trade, Foreign Investment, and Industrial Policy for Developing Countries." In *Handbook of Development Economics*, Vol. 5, edited by Dani Rodrik and Mark Rosenzweig, 4039-214. New York: Elsevier.

Hilton, Stanley E. 1975. "Vargas and Brazilian Economic Development, 1930-1945: A Reappraisal of His Attitude Toward Industrialization and Planning." *The Journal of Economic History* 35(4): 754-78.

Hochstetler, Kathryn, and Alfred P. Montero. 2013. "The Renewed

Developmental State: The National Development Bank and the Brazil Model." *Journal of Development Studies* 49(11): 1484-99.

Hosono, Akio, Nobuaki Hamaguchi, and Alan Bojanic. 2019. *Innovation with Spatial Impact: Sustainable Development of the Brazilian Cerrado*. Tokyo: Springer.

IEA (International Energy Agency). 2019. "How Competitive is Biofuel Production in Brazil and the United States?" https://www.iea.org/articles/how-competitive-is-biofuel-production-in-brazil-and-the-united-states.

Kupfer, David, João C. Ferraz, and Felipe S. Marques. 2013. "The Return of Industrial Policy in Brazil." In *The Industrial Policy Revolution I: The Role of Government beyond Ideology*, edited by Joseph E. Stiglitz and Justin Y. Lin, 327-39. London: Palgrave-Macmillan.

Landesmann, Michael A., and Roman Stöllinger. 2019. "Structural Change, Trade and Global Production Networks: An 'Appropriate Industrial Policy' for Peripheral and Catching-up Economies." *Structural Change and Economic Dynamics* 48: 7-23. https://doi.org/10.1016/j.strueco.2018.04.001.

Lazzarini, Sergio, Aldo Musacchino, Rodrigo Bandeira-de-Mello, and Rosilene Marcon. 2014. "What Do State-Owned-Development Banks Do? Evidence From BNDES, 2002-09." *World Development* 66: 235-53.

Maffioli, Alessandro, João A. de Negri, Cesar M. Rodriguez, and Gonzalo Vasquez-Bare. 2017. "Public Credit Programmes and Firm Performance in Brazil." *Development Policy Review* 35: 675-702.

Matsuyama, Kiminori. 1997. "Economic Development as Coordination Problems." In *The Role of Government in East Asian Economic Development*, edited by Masahiko Aoki, Hyung-Ki Kim, and Masahiro Okuno-Fujiwara, 134-60. Oxford: Clarendon.

Mazzucato, Mariana. 2011. *The Entrepreneurial State*. London: Demos.

——. 2015. "Innovation Systems: From Fixing Market Failures to Creating Markets." *Intereconomics Review of European Economic Policy* 50(3): 120-25.

Musacchio, Aldo, and Sergio G. Lazzarini. 2014. "State-Owned Enterprises in Brazil: History and Lessons. Mimeo, OECD. https://doi.org/10.1787/9789264229617-6-en.

Oqubay, Arkebe, and Kenichi Ohno, eds. 2019. *How Nations Learn: Technological Learning, Industrial Policy, and Catch-up*. Oxford Scholarship Online.

Peres, Wilson, and Annalisa Primi. 2019. "Industrial Policy and Learning: Lessons from Latin America." In *How Nations Learn: Technological*

Learning, Industrial Policy, and Catch-up, edited by Arkebe Oqubay and Kenichi Ohno, 207-34. Oxford: Oxford Scholarship Online.

Petrobras. 2020. *Relatório da Administração 2019*. https://www.investidorpetrobras.com.br/resultados-e-comunicados/relatorios-anuais/.

Rodrik, Dani. 2008. "Normalizing Industrial Policy." Commission on Growth and Development Working Paper No. 3. Washington, DC: World Bank.

——. 2016. "Premature Deindustrialization." *Journal of Economic Growth* 21(1): 1-33.

Schwab, Klaus. 2015. "The Fourth Industrial Revolution: What It Means and How to Respond." *Foreign Affairs*. December 15, 2015. https://www.foreignaffairs.com/articles/2015-12-12/fourth-industrial-revolution.

Shapiro, Helen. 1994. *Engines of Growth: The State and Transnational Auto Companies in Brazil*. Cambridge: Cambridge University Press.

Stiglitz, Joseph E. 2017. "Industrial Policy, Learning and Development." In *The Practice of Industrial Policy: Government-Business Coordination in Africa and East Asia*, edited by John Page and Finn Tarp, 23-39. Oxford: Oxford University Press.

Suzigan, Wilson, and João Furtado. 2006. "Política Industrial e Desenvolvimento." *Revista de Economia Política* 26(2): 163-85.

Tavares, Maria da Conceição, Hildete Pereira de Melo, Ana Claudia Caputo, Glória Maria Moraes da Costa, and Víctor Leonardo de Araújo. 2010. "O Papel do BNDE na Industrialização do Brasil – Os Anos Dourados do Desenvolvimentismo 1952-1980." In *Memórias do Desenvolvimento*, Numero 4, 133-57. Centro Internacional Celso Furtado de Políticas para o Desenvolvimento.

Tigre, Paulo B. 1995. "Liberalização e Capacitação Tecnológica: O Caso da Informática Pós-Reserva de Mercado no Brasil." In *Ciência e Tecnologia no Brasil: Política Industrial, Mercado de Trabalho e Instituições de Apoio*, edited by Simon Schwartzman, 179-204. Rio de Janeiro: Editora FGV.

Torres, Ernani, and Rodrigo Zeidan. 2014. "The Life-Cycle of National Development Banks: The Experience of Brazil's BNDES." *The Quarterly Review of Economics and Finance* 62: 97-104.

Wade, Robert H. 2016. "Industrial Policy in Response to The Middle: Income Trap and the Third Wave of the Digital Revolution." *Global Policy* 7(4): 469-80.