The science and technology race and productive re-structuring:

geoeconomic and geopolitical impacts

Corrida científica e tecnológica e reestruturação produtiva:

Impactos geoeconômicos e geopolíticos

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Abstract: The accelerated growth of the Chinese economy and of other Asian countries has broadened the participation of the Asian bloc in international production and trade. This process has changed economic geography and global order, thereby creating a strong challenge to Western capitalism, which is undergoing a structural crisis, seeking to recover its relative position. The consequence of the competition between the two blocs has been a rapid science and technology race. On the other hand, Brazil has experienced a speedy process of deindustrialization and a reduction of investment in R&D, which may also hinder the ongoing productive deconcentration. The difficult industrial recovery and the preservation of the regional deconcentration process requires the structuring of a new, affirmative industrial policy with a long-term view, and an emphasis on science and technology. It should also guarantee the consolidation of ongoing projects and afford special attention to taking advantage of regional potentials with a view to broadening the trends of territorial decentralization.

Keywords: Chinese growth, Asian expansion, global crisis, technology race, Brazilian de-industrialization, industrial policy, science and technology policy, regional development.

Resumo: O crescimento acelerado da economia chinesa e de outros países asiáticos vem ampliando a participação daquele bloco na produção e no comércio internacional de manufaturas. Esse processo altera a geografia econômica e a ordem global, provocando forte desafio ao capitalismo ocidental, que se encontra em crise estrutural e busca recuperar sua posição relativa. A competição entre os dois blocos é condicionada por uma acelerada corrida cientifica e tecnológica. Ao contrário, o Brasil vem passando por rápido processo de desindustrialização e de redução dos investimentos em P&D, o que poderá comprometer, também, a desconcentração produtiva em curso. A difícil recuperação industrial e a preservação do processo de desconcentração regional exigem a montagem de uma nova e afirmativa política industrial, com visão de longo prazo e ênfase em ciência e tecnologia. Ela deverá também garantir a consolidação dos projetos em andamento e dedicar especial atenção ao aproveitamento das potencialidades regionais com vistas a ampliar as tendências de desconcentração territorial.

Palavras-chave: crescimento chinês, expansão asiática, crise global, corrida tecnológica, desindustrialização brasileira, política industrial, política científica e tecnológica, desenvolvimento regional.

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INTRODUCTION

The present work aims to analyze the relative position of Brazilian industry and its regional composition given the profound technological and geographic transformations of world industry. The work has been divided into four sections, apart from this introductory paragraph. In the first section, the industrial expansion of Asia and its effects on the reconfiguration of the world economy is analyzed. The second will examine the science and technology race and the struggle of the West towards reindustrialization as a strategy to confront Asian expansion, particularly from China. In the third, the main challenges for Brazilian industrial development are identified in view of the recent processes of deindustrialization and denationalization, the global race in science and technology and the risks of compromising the process of regional deconcentration. In the fourth and final section, the main challenges and requirements of industrial policy are indicated, with particular emphasis on science, technology and regional policies.

THE INDUSTRIAL EXPANSION OF ASIA AND ITS IMPACTS ON THE WEST

Although the weight of central capitalism, represented by the OECD and under the leadership of the G7, remained high, from the 1970s onwards, it has had to face successive structural crises. This process began when the dollar-gold convertibility was ended in 1971, followed by the oil crises of 1973 and 1979, the generalization of the inflationary process, the growth of the public deficit in the 1980s, the structural crisis in the European Union, and culminating in the collapse of the financial system in 2008. On the other hand, a significant part of the periphery continued to grow, reducing the relative weight of so-called central capitalism in both the GDP and world exports (TABLE 1). This relative loss became more pronounced during the first two decades of the 21st century, with the rapid expansion of Asia and other peripheral regions, thereby hindering global governance by the G7, which is why the G20 was created. Between 1990 and 2014, manufacturing production in the so-called developing and emerging industrial economies, comprising 32 countries, including China, India, Mexico, Brazil and Turkey, grew by 290%, thereby increasing its participation in world industrial production from 18% to 36%, while over the same period industrialized countries grew by 50% (UNIDO, 2015, p.173).

What has been observed is the accelerated growth of the Chinese economy, which has become the second world economy, threatening to take over the lead, as predicted by Arrighi ([2007] 2011) through the suggestive title of his book *Adam Smith in Beijing*. Between 2000 and 2015, China's share of manufactured exports soared from 5% to 19% of the world total, thereby moving into top position in both manufacturing and manufacturing exports (Graphs 1 and 2).

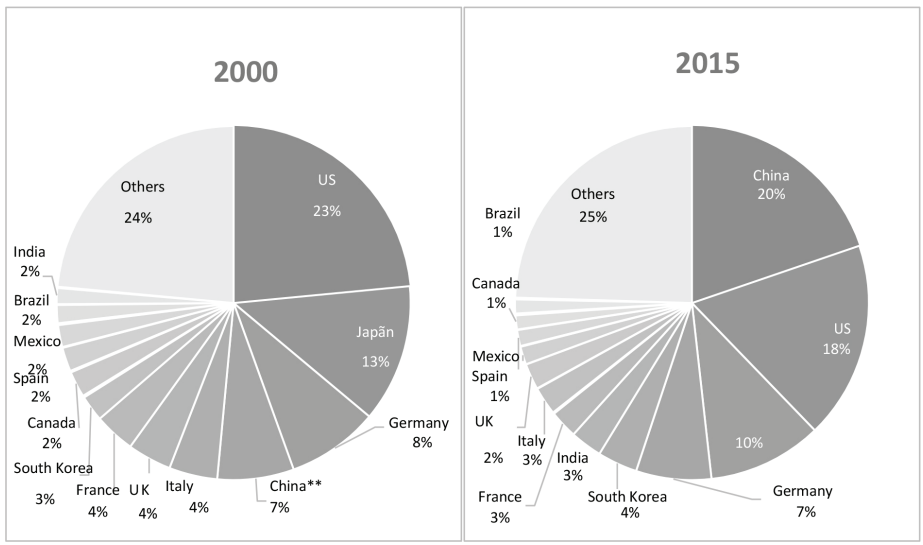
TABLE 1 – Selected continents and countries: Area, Population, GDP and Exports, 1980,2000 and 2015 (US$ – constant values from 2005)

Country or Region			Population		GDP		Exports		
					1980	2015	1980	2000	2015
	Mi. Km²	**%**	**Millions**	**%**	**%**	**%**	**%**	**%**	**%**
Africa	30,0	22,4	1170,4	16,0	2,3	2,8	5,2	2,9	2,5
US & Canada	19,8	14,8	354,7	4,8	28,5	27,4	14,7	16,1	12,9
Latin Am.& Caribbean	20,4	15,2	635,4	8,7	6,9	6,2	5,6	5,8	5,0
Asia	32,0	23,8	4401,9	60,0	18,8	31,8	25,1	26,9	36,2
Oceania	8,6	6,4	38,6	0,5	1,8	1,9	1,6	1,8	1,5
Europe	23,1	17,2	733,1	10,0	41,6	29,8	47,7	46,5	41,9
World	**134,3**	**100**	**7334,2**	**100**	**100,00**	**100,0**	**100,0**	**100,0**	**100,0**

Sources: Area and Population – DataBank, World Bank, 2015 data; GDP and Exports – United Nations Statistics Division (National Accounts Official Country Data).

As from the 1980s, the Chinese economy underwent profound political and economic restructuring, emphasizing economic growth through building a modern export sector, creating special economic zones, attracting foreign investment, and, then later, innovation (DUNFORD, 2015). Outstanding within this process was the introduction of the concept of "socialist market economy" adopted by the 14th Congress of the Communist Party of China in 1992, configuring what Liu (2015) termed the Chinese 'Third Way', which combines the coordination of a strong market and state with a weak society.

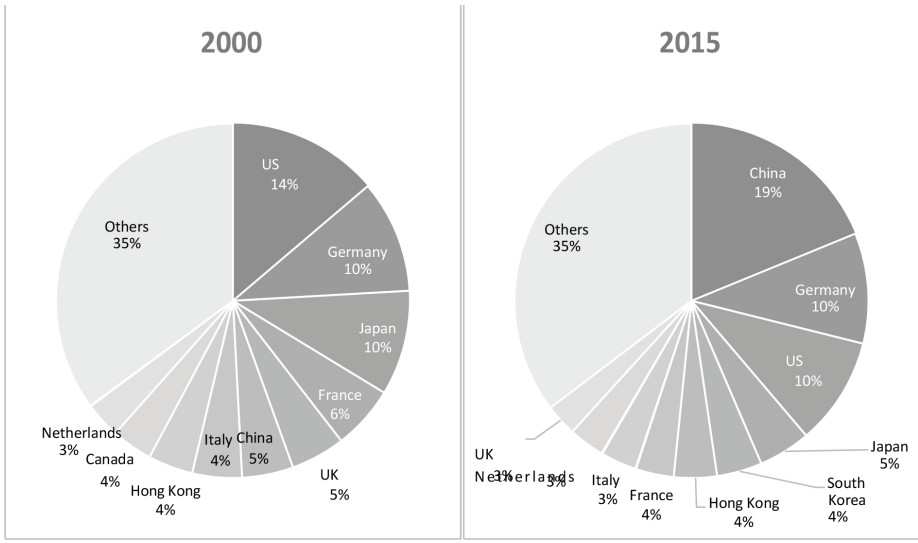
Graph 1 – Relative participation in manufacturing production (US$ and constant prices from 2005)



Source: United Nations Statistics Division (National Accounts Official Country Data).

**Absent in the original source data. Collected from the World Bank National Accounts Data and deflated according to China's implicit GDP deflator

Figure 2 – Relative participation in the manufacturing exports (US$ and current prices)



Source: World Trade Organization Statistics Database (Time Series on International Trade).

Contrary to some historical interpretations, Chinese growth has not only relied on simple manufacturing and cheap labor. These elements were initially important. However, from the outset, they were linked to a political strategy so as to condition foreign investments to internalize research efforts, as well as to implement a vigorous expansion process within its research system, through the Chinese Academy of Sciences and its institutes, and the university system (QIAOJUAN and AIXIU, 2010). Between 2000 and 2015, in China, there was a ten-fold increase in the number of scientific articles published in English, growing from 43,000 to 471,000. As a result, China moved from 6th position up to 2nd position worldwide, threatening to reach and overtake the United States (US) within a few years. Although the impact index is still relatively low, the expansion and modernization of the academic and research system, and its linkage to the country's economic policy, indicate that, over time, China will also play a leading role amongst science and technology leaders, supporting its process of technological modernization, innovation and competitive capacity.

In similar terms, the number of patent applications has also risen from 51,906 to 1,101,864, taking it from 5th position to 1st, according to the World Intellectual Property Organization (WIPO). Scientific effort has been linked to technological modernization, which together has placed China in a prominent position, as indicated not only by the growth of manufacturing production and exports, but also by the strengthening of Chinese business groups. Within this orientation, in 2006, guidelines for the National Medium and Long-Term Program for Science and Technology Development (2006-2020) was launched. The program established detailed objectives, targets and means that have been adjusted through the five-year plans and annual budgets. Outstanding are the Accelerated emerging industries (2010), Internet plus (2015) and Made in China (2025), with nine major goals or objectives to be achieved by 2025 (OECD, 2017), with a view to assuming world technological leadership in various sectors. In addition to the growth of domestic production, Chinese companies have also increased their overseas investments (LIU & DUNFORD, 2016).

Over recent years, given the difficulties of maintaining the pace of export growth, China has established a process of economic restructuring. Drawing on the experience of reforms from the three previous decades, it has defined new directions for the next three decades, as detailed and described by Chi Fulin (2010), President of the Chinese Institute for Reform and Development, in *The Road to China's Prosperity in the Next Three Decades*. These guidelines were formalized in the 13th Five-Year Plan (2016-2020), which establishes the reorientation of the Chinese model, with emphasis on exports, expansion of the domestic market, the reduction of regional and social inequalities, and the pursuit of sustainability and environmental control. To do so, it has combined a heavy infrastructure investment program, support for rapid urbanization, improved living conditions for the rural population, with strong support for the science, technology and innovation systems.

It should be noted that, prior to the recent economic transformations in China, the Russian, Chinese and Cuban revolutions and the end of the Korean war encouraged world capitalism, for strategic geopolitical reasons, to prevent the advance of socialism in Asia. Thus, explicit, emphatic support was provided for the economic recovery of Japan and for the economic expansion of South Korea and Taiwan. Central capitalism opened the markets for the industrial products from these countries, in addition to Hong Kong, then under British rule.

South Korea established a development strategy that prioritized education and technology, with an emphasis on exports. With no foreign direct investment, Korean industry also began reverse engineering, making it one of the most modern and efficient industrial systems in the world (AMSDEN, 1989). Between 1970 and 2014, Korea soared from 42nd position to become 5th in the world ranking of manufacturing production (RHODES, 2016).

A similar trend also followed in a group of other small Asian countries, as reported by Schlossstein (1991) in Indonesia, Thailand and Malaysia, and with the more recent expansion in Vietnam.

In another context, but in parallel, since the 1970s, India has also embarked on a modernization process, which began with the so-called green revolution (seeds and fertilizers) and was followed by a major effort to industrialize and build infrastructure. Outstanding within this context is the historical legacy laid down by the post-independence (1947) leaderships of Mahatma Gandhi, Jawaharlal Nehru and Indira Ghandi, the role of a good scientific base at a number of universities and the creative atmosphere of debate that was established at the coffee house in the Delhi School of Economics from the 1980s (BASU, 2015).

The crisis of the early 1990s led to a profound restructuring of Indian economic policy. It combined a modernization effort with openness to foreign capital markets, which resulted in a major growth of industry and services. As a consequence, the weight of the sum of exports and imports in the GDP rose from 14% in the early 1990s to 36% in the period 2010-11. The investment rate on GDP rose from between 17% and 20% in the 1970s and 1980s to 25% in the 1990s and 35% in 2000 (BASU, 2015, p.19). The average economic growth was 4.5% per year in the period 1973-1993 and 7% per year in the period 1994-2014. Of particular note was the growth of the service sector in information and communication technologies, together with the software industry (ARORA & ATHREYE, 2002). In addition to good technical skills and higher education, the development of a bilingual system was also central

to providing a solution for the linguistic fragmentation throughout the country. The concentration of people in industrial and service activities brought about the search for a common language of communication, thereby resulting in a robust bilingualism, which maintained the original languages and developed English (CLINGINGSMITH, 2008). The growth and modernization of services (banking, telecommunications, insurance, transportation, etc.) had a great effect on the productivity growth of industry, as indicated by Arnold et al. (2012), taking India from 23rd to 6th position in world ranking of manufacturing production (16). Furthermore, growth in industrial exports and services enabled an increase in international reserves from $ 5 billion to $ 300 billion between 1991 and 2008. As a consequence of economic growth, the percentage of the population below the poverty line fell from 66% in 1977 to 22% in 2012 (KNIIVILA, 2007; BASU, 2015, pp. 19-21).

What may be observed from the rapid process of Chinese industrialization, the expansion of Korea and other smaller Asian countries and the recent Indian expansion, is that the old traditional regions have been placed at a distinct disadvantage. The data in Table 1 demonstrates that, between 1980 and 2015, the weight of the US, Western European and Japan in world GDP and in exports fell from 78% and 64% to 63% and 57%, respectively

Although the entire periphery experienced relatively small gains, the great growth occurred in Asian countries, with the exception of Japan, whose share rose from 8% to 23% of GDP and from 19% to 32% of exports.

In contrast to the rapid Asian expansion, after the period of accelerated and generalized economic growth during the so-called glorious thirty years (1945-75), Western capitalism and its peripheries entered deep structural crisis. The main manifestations of this crisis may be summarized as follows: (a) the abandonment of dollar-gold convertibility by the US in 1971; b) the crisis of Fordism and the deindustrialization of central countries from the 1970s; c) oil shocks in 1973 and 1979; d) the economic crisis in Japan, Russia and peripheral countries (Mexico, Thailand, Brazil, Argentina) in the 1980s and 1990s; e) a generalization of neoliberal policies and changes in the role of the state, with external openness, privatizations, abundance of credit and general indebtedness; f) economic crisis in Europe; g) the attack on twin towers (2001); h) a shift from financial wealth relative to real wealth, with widespread financialization in 2008. All this was then magnified by the property bubble, subprime lending and the bankruptcy of the Lehman Brothers Bank in the US, thereby causing panic on the world markets and generalizing the crisis.

Thus, several authors from differing theoretical and political affiliations have analyzed and synthesized the manifestations of this crisis: structural unemployment, the proliferation of nuclear weapons, mass migration, institutional weakness, religious fundamentalism, ethnic movements, widespread corruption, concentration of income and wealth, global warming, climate change, digital insecurity, scientific and technological gnosticism, market domination over the state, commodification without frontiers (WALLERSTEIN et al., 2013; BECK, 2016; STREECK, 2016). These findings have led to the conclusion of the unpredictability of capitalism. However, it remains unclear as to how capitalism will end, what will replace it, and how and when the transition will take place. There is also a certain consensus that capitalism has demonstrated an ability to adapt and reinvent itself according to historical circumstances.

THE SCIENCE AND TECHNOLOGY RACE AND THE WEST'S STRUGGLE FOR REINDUSTRIALIZATION

Given the multiple ongoing crises and fierce competition (economic, political, military, geopolitical), the environmental challenge and the extraordinary scientific advances, the world has entered an accelerated science and technology race, as observed by the number of scientific articles published, the expenditure on research and development and by the profound changes in production, management and distribution patterns. In this regard, *Global R & D* (2017) provided an analysis of the relative position of the main countries with significant investment in R & D. In 2015, R & D expenditure was estimated at US$1.9 trillion, representing 1.7% of world GDP, with forecasts for 2017 exceeding US$ 2.1 trillion. Although the average global spending on R & D is 1.7% of GDP, in Korea it is over 4%; Japan, Sweden, Israel, Finland spend more than 3%; Germany 2.9%, the US 2.8%; and China 1.9%, to mention the most relevant. In relative terms, the Brazilian average was 1.2%, with subsequent estimates of decline over recent years, reflecting the economic crisis with a retraction in R & D expenditure in both the public and private sectors.

The results of the scientific effort as a basis and support for technological and innovative advancement are extensive worldwide and are well documented in a wide range of literature and in a series of publications by leading international organizations dealing with related issues. Although with different diagnoses and political proposals, they are dedicated to analyzing the behavior of international trade, and of industrial performance, which may be observed by the very name of these publications and their contents:

a) *Industrial Development Report 2016*, (UNIDO, 2015), with the subtitle *The role of technology and innovation in inclusive and sustainable industrial development*;
b) *The next production revolution: implications for Governments and Business* (OECD, 2017). In addition to a broad and detailed analysis of the role of science and technology, of the new technological frontiers, it also brings specific analyzes of the science and technology races of the US and China as weapons in the competitive, economic and geopolitical struggle;
c) *Trade and development report, 2016* (UNCTAD, 2016), with the subtitle *Structural transformation for inclusive and sustained growth*. In addition to a detailed analysis of international trade, its role and its behavior, it also provides a specific analysis of the so-called "*catch-up challenge: industrialization and structural change*".

Unlike the great historical technological transformations, well characterized by the sectoral trajectories, the so-called "Kondratieff cycles" (FREEMAN & LOUÇÃ, 2001; LASTRES & FERRAZ,n/d.) (textiles, coal and steel railroad, electricity and chemistry, oil, cars and consumer goods, ICT), the ongoing transformations indicate multiple trajectories: ICT and artificial intelligence combined with precision engineering and new materials, with effects on automation, robotization, 3D printing, internet of things; advances in natural and synthetic biology, and their effects on the bioeconomy, including new energy sources; and new materials with the advancement

of nanotechnologies. Added to this is the fact that the energy and environmental mega-paradigms maintain major, permanent scientific, technological, social and political challenges, pushing towards the search for new solutions. There are also great opportunities for exploiting biodiversity, while at the same time increasing the risks of environmental sustainability.

At these different scientific and technological frontiers, there is a growing multidisciplinary combination. These may be, in many cases and at the same time, paradoxically disruptive and confluent. Disruptive because they break with an evolutionary logic. Confluent because they may build common bases by means of digitization, robotization, artificial intelligence and their combinations, bringing new opportunities and new challenges to science and technology.

The gnostic nature of this race, placing science and technology above human and social values and the unpredictability of its economic, social, political and environmental consequences have placed the future of humanity at risk (MARTINS, 2013, DINIZ, 2015, DINCAO, 2015).

Faced with such a profound, rapid change in the world scenario, in the relative loss of the productive and commercial leadership of the so-called central capitalism and in the Asian technological threats, extensive industrial modernization programs have recently emerged, aimed at recovering the industrial capacity of the most industrialized countries in Western Europe, members of the European Union, and in the US. Even in the early 1980s, the UK, for the first time in its history, began to show a deficit in the manufacturing balance. Although Germany has maintained its relative weight in manufactured exports and is implementing a vigorous process of technological modernization, and some European countries still have a favorable balance, the situation is nonetheless deteriorating with Asian competition. Between 1990 and 2014, Europe's share of world manufacturing output fell from 41% to 28% and manufacturing weight in the GDP to 16% (UNIDO, 2015 p.282).

In 2001, for the very first time, the US manufacturing balance showed negative, and continued to widen over the following years. Between 2000 and 2010, US manufacturing employment fell from 17 million to 12 million. Productivity growth fell from an average of 4.1% per year between 1989 and 2000 to 1.7% between 2007 and 2014. By 2015, the US manufacturing balance deficit had reached $ 832 billion, of which $ 92 billion was deficit from high-technology manufacturing (OECD, 2017, pp. 362-3).

Given this scenario, and with a view to recovering the industrial capacity of these regions, several national or regional programs have been launched aimed at reindustrialization. Of particular note are the Advanced Manufacturing National Program Office, launched by the US Presidency in 2011 (NSTC, 2013) and renamed Manufacturing USA in 2016 (OECD, 2017, p.374). The program proposed the creation of 15 institutes aimed at manufacturing innovation through a partnership between industry, universities and government, which would establish a joint governance and management system. Initially, the program was led by the former chairman of Dow Chemical and MIT President. At the beginning of 2017, there were 14 institutes in operation, eight of which were supported by the Department of Defense (NNMI, 2016, OECD, 2017, pp. 375-395). Thus, it is widely known how important military spending has become within US science and technology policy and its consequences on US industry (MARKUSEN et al., 1991). To this may be added

the recent protectionist orientations of the Trump Administration, the consequences of which are still unpredictable.

The Factories of the Future program, developed by the European Factories of the Future Research Association (EFFRA), and launched by the European Union, stresses the importance of industry for the European Union, indicating research objectives and priorities and laying the foundations for public-private partnerships. It anticipated a volume of resources totaling € 7 billion over a period of seven years, to be applied between 2013 and 2020. It was hoped that the dissemination of innovations would leverage additional resources for research and innovation. This program, however, encountered two major difficulties. First, the crisis in the European Union and the difficulty of financing the program. Second, the different interests between European countries, which have deepened with the region's structural crisis, which has led to the implementation of individual programs in practically all countries.

The most prominent example is the so-called "Industry 4.0" in Germany, an expression conceived in 2011 during the Hannover Fair, motivated by the search to understand the current technological changes, and the paths and challenges for strengthening the capacity of competition in German industry. The concept of "Industry 4.0" overcomes the historical and conventional view of manufacturing and analyzes the integrated effects on all productive activities, factories, production chains and logistics based on online computing systems, integrating economic and social processes in real time, including government and public bodies.

Because of its breadth and scope, the concept of "Industry 4.0" breaks with current standards, so it is understood as a disruptive paradigm. This program seeks to combine additive manufacturing with 3D printing, generalized scanning, artificial intelligence, robotization, amongst others, and aims to build intelligent factories to keep Germany in the lead, especially in production assets (instrumentation, machines, equipment) (IEDI , 2017). This new productive pattern will have high requirements for management efficiency and connectivity (MACKINSEY, 2015). Mention is also made of the Catapult Programme in the UK, and the UK's recent decision to break away from the European Union, formalized with the approval of Brexit. Most other European countries, each in its own way, have implemented technological modernization programs, especially in the business system, as indicated by expenditure on R & D in countries such as Finland, Sweden, Switzerland, Austria, Belgium, Denmark and the Netherlands.

In the case of Brazil, the impacts of Industry 4.0 have been well explored in the analyses developed by different specialists related to the main productive sectors, also indicating the relative backwardness of the country (ESPECIAL INOVAÇÃO, 2017; KUPFER, 2017).

DEINDUSTRIALIZATION AND REGIONAL DECONCENTRATION IN BRAZIL

From the industrial expansion after WWII to recent deindustrialization

Although peripheral and dependent, Brazil made a productive leap during the post-World War II period, with significant structural changes, such as the major growth

and diversification of industrial production, rapid urbanization and, later, accelerated modernization of the agricultural and cattle ranching sector[1] [1]. From the viewpoint of manufacturing, there are two outstanding points: growth during the 1950s, through the Targets Program, with the expansion of the intermediate goods industry (steel and cement), durable consumer goods (automotive), and traditional industry, especially textiles and food. However, the accelerated internationalization of sectors in which Brazil began to develop ultimately annihilated these initiatives, making it impossible to strengthen companies and national groups (MIRRA & SALEMO, 2015). The second point was the growth and industrial diversification of the 1970s, under the auspices of the II PND, with relative industrial diversification and expansion of the capital goods industry, and the emergence and expansion of national industries in the latter segment. As a result, between the early 1950s and the mid-1980s, the weight of manufacturing in the GDP rose from 12% to 23%. This enabled Brazil, in 1980, to attain 9th place in the world ranking of industrial production, with approximately 2.5% of the total (MORCEIRO, 2016). This position was overtaken by only six countries (the US, Japan, Germany, Italy, the UK and France), in the absence of statistics for Russia and China (RHODES, 2016). As China had not yet demonstrated its strength, it was expected that, in keeping with the pace of expansion of the 1970s, Brazil could reach 4th position in the world ranking of industrial production, thereby overtaking Italy, the UK and France, thereby becoming an emerging industrial powerhouse. While analyzing Brazilian industrial growth of the period, Castro and Souza (1985) concluded that in the mid-1980s, Brazil possessed an integrated, almost complete industrial structure. It had expanded its capital goods industry, with several national and private national groups, and had attracted several foreign industries from within the sector.

However, the economic crisis of the 1980s and 1990s - with the growth of foreign debt and raging inflation -, the form of economic openness abroad, the privatization process linked to the neoliberal orientation of the "Washington Consensus" and the incompatibility of a macroeconomic policy with an industrial policy led Brazil through to a continuous process of de-industrialization. The most serious problem was that, in addition to jeopardizing Brazilian industrial growth, it also generated its disparity, especially in the production goods sector

The resumption of Brazilian economic growth in the early 2000s was accompanied by a major expansion of consumption, without the corresponding increase in investments and national manufacturing production, with the consequent expansion of imports of industrialized goods. This phenomenon was due to several simultaneous factors: an increase in consumption demand due to GDP growth; a real increase of the minimum wage; distribution policies and income transfers by the Federal Government (rural retirement, family benefits, Annual Budget Law - LOA, etc.). The increase in imports of industrialized goods was facilitated by the increase in the balance of payments due to the increased exports of agricultural commodities and minerals. Export growth was facilitated by increased international demand, especially from China, by improved trade terms and by an overvalued exchange rate. Strictly speaking, the exchange rate had been valorized since the implementation of the Real Plan, which, together with high interest rates, stimulated the entry of speculative and

1 In this case, thanks to the success of the programs implemented by EMBRAPA, which bridged the research developed in universities and in their own research centers with the productive sector. Also important was the role of the producer cooperatives, which served as a channel to support and induce the productive modernization of their members.

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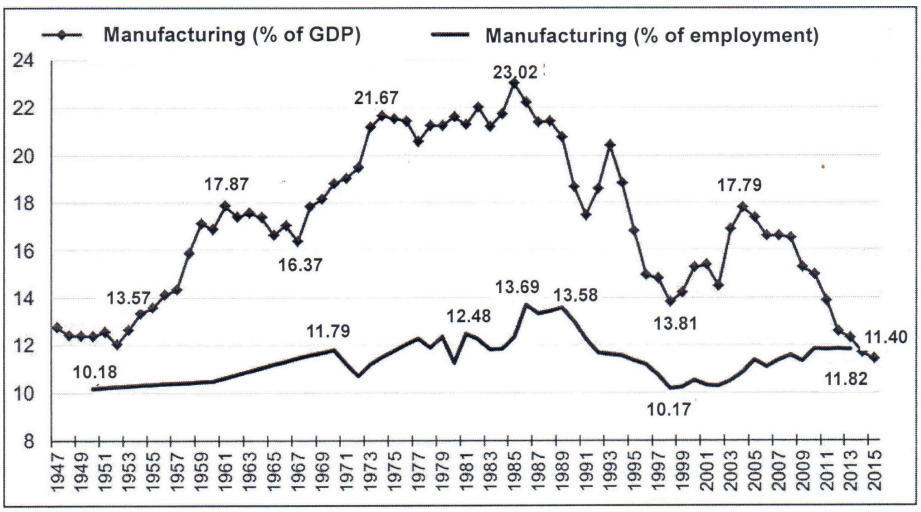
rentier capital. The balance of international currencies was expanded, characterizing a typical Dutch disease (BRESSER PEREIRA, 2010). As of 2006, the manufacturing trade balance began to show increasing deficits. Between 2003 and 2013, domestic demand for manufactured goods grew by 60%, while domestic production grew by only 34%, increasing the share of imports for the domestic demand, especially in medium and high technology activities. During this period, the share of imported manufactured goods in the final demand rose from 14% to 27%, and in the most advanced technology sectors, growth was more significant, rising from 25% to 41%. As a consequence, the manufacturing trade balance went from a surplus of 2.7% of manufacturing production to a deficit of 16.5% (MORCEIRO, 2016). According to Sarti and Hiratuka (2017), between 2009 and 2014, Brazilian participation in world exports of manufactured goods fell from 0.8% to 0.6%, while imports increased from 0.5% to 1.4%. In addition to the growth in imports of final goods, imports of intermediate goods, especially parts and components, also increased significantly. The result has been a continuous loss of industrial weight in the GDP (Graph 3), a rapid denationalization process of Brazilian industry and a drop in the importance of the more advanced technology segments. As a consequence, Brazilian manufacturing production dropped from 9th position to 13th in world ranking, falling from 31% to 11% of the share of manufacturing value added in GDP (RHODES, 2016).

Graph 3 – The share of manufacturing in the GDP and employment



Source: MORCEIRO (2016).

Despite the drop in the share of manufacturing in the GDP being a widespread phenomenon in most industrialized countries, the levels of the Brazilian drop indicate or prove an early and marked process of deindustrialization. Considering the economic crisis and the fall in manufacturing production, it is estimated that this share has dropped to levels below 10% and, consequently, its position in the world ranking has also dropped significantly. This situation, coupled with a drop in the gross capital formation rate, according to Coutinho and Kupfer (2015), indicates an even worse prospect, the destruction of Brazilian industry, despite great potential in several sectors. By way of comparison, countries such as Germany and Japan still maintain a manufacturing percentage in the GDP of more than 20%.

Added to this are the historical structural problems, which affect the productivity of Brazilian industry, such as low physical capital formation, a poorly qualified labor force and a low capacity and willingness to promote innovations. To these are added the problems of deficient infrastructure and imbalances in the tax burden. This set of elements therefore affects, jointly and cumulatively, the productivity and competitiveness of Brazilian industry (BARBOSA et al., 2017, SARTI & HIRATUKA, 2017, CANUTO & DE NEGRI, 2017).

The Brazilian situation is paradoxical. On the one hand, these results have been provoked by the macroeconomic policy, while on the other, the country has implemented numerous programs and measures to support industrial modernization. These have included the Informatics Law, *Brasil Maior, Inova-Auto*, *Inova-Empresa*, *Lei do Bem*, besides subsidized credit and tax exemption. There was also an increase in the political awareness of entrepreneurs through MEI and IEDI and the new operational arrangements established by SIBRATEC through the SENAI and EMBRAPII systems. Despite all this effort, the results, in terms of technological modernization and productivity increase, have been modest. According to De Negri (2016, p.5), "the realization that the Brazilian State has increased the volume of resources and the set of policies for innovation without achieving significant results - even in the pre-crisis, when the country's economy was growing – is, at the very least, worrying." In other words, the country's macroeconomic policy and structural problems have nullified the effects of industrial and technological policies. In addition to this, expenditure on industrial incentives have generated a major negative impact on tax revenue and the costs of subsidized funding, but have had little effect on the growth of industry.

Despite the funding efforts made over the last few years, there has been no increase in R & D expenditure in relative terms. Besides the relatively low expenditure in relation to other countries, of the total of 1.2% of the GDP estimated as expenditure on R & D, the public sector participated with 60% against 40% of the private sector. This situation is totally different from countries that are in the science and technology race, where private spending is higher than 70%. This becomes even more serious since a significant portion of private sector spending in Brazil originates from subsidized public funding and from the fiscal waivers.

It should also be noted that this was a period when there were giant leaps in Brazilian science and in training human resources. Between 2000 and 2015 the number of students enrolled in higher education rose from 2.7 million to 7.2 million, the number of graduates with a master's degree rose from 17 to 40 thousand, the number of doctorates from 5 thousand to 17 thousand, and the number of articles from 14 thousand to 68 thousand. A large expansion program was implemented for federal universities together with the implantation of numerous Federal Institutes for Technology Education (IFTs), both through REUNI, as well as support for the expansion of private education through PROUNI and FIES. All this confirms the paradoxical or contradictory situation of public policies in Brazil.

The process of regional industrial deconcentration and its risks

Industrial expansion in Brazil since the 1970s has been combined with a process of regional deconcentration, whereby all Brazilian regions have gained a relative share,

to the detriment of São Paulo and Rio de Janeiro. This process has been analyzed in a broad literature (AZZONI, 1986; DINIZ & CROCCO, 1996). Even after the industrial expansion subsided from the 1980s, the differentiated growth between regions remained, as indicated in Table 2.

Related to this process of industrial deconcentration, or conjugated to it, numerous macro-spatial changes began to take place in Brazil. First, due to the great expansion of the agricultural and mineral frontiers, promoting the growth of production in the Central-west, North, and the western part of the Northeast (MATOPIBA) and irrigated agriculture in several hydrographic basins within in this latter region. Second, the horizontal effects of social policies on the more backward regions, especially in the Northeast. The transfer of income through rural retirement, LOA and *Bolsa Família* (Family Benefits) monetized the poorest population, thereby expanding the consumer goods market. Added to this is the expansion and commodification of family agriculture, fuelling economic growth and demand. Third, due to the great impact of education and health policies, especially in small and medium-sized towns. Fourth, through the combination of investments in infrastructure, particularly ports (Itaqui, Pecém, Suape), railroads, and airports in the main capitals of the country. Finally, for the industrial investment package sponsored by the Federal Government, especially in the Northeast (refinery, shipyards, petrochemicals, automotive, pulp, power plants, urban infrastructure, wind farms, etc.). This set of projects, initiatives and investments generated a strong effect on employment and income, expanding the regional market, stimulating and promoting the location of new units producing consumer goods, especially food, beverages, changing rooms, appliances, etc. in retail networks and in commerce. All this led to a process of relative change within the economic and social framework of the regions, as indicated by changes in the relative share in the GDP (Table 2).

The major concern with regional development is the devastating effect of the current crisis on recent or ongoing projects, several of them linked to the oil complex, such as in the Northeast (shipyards, refineries, petrochemicals). On the other hand, the great challenge is related to the impacts of the global productive restructuring and its recovery in Brazil, especially due to its accelerated science and technology race. As the greatest economic density and science and technology infrastructure is predominantly located in the Southeast and Southern regions of Brazil, the potential impacts of productive restructuring may affect the process of economic and industrial deconcentration within the country, especially for the heavily-populated and economically backward Northeast.

It is therefore central that industrial, science and technology policies have a specific concern with the regional issue in Brazil, reinforcing the research effort in less developed regions, maintaining and expanding the system of higher education and research recently implemented or expanded as a lever for productive modernization and for the exploitation of regional potential.

Table 2 – Participation of the Major Regions and Federal States in the Gross Domestic Product and the Manufacturing Value – 1970-2015

Brazil, Major Regions and Federal States	GDP (%)				Manufacturing Product (%)			
	1970	1980	2000	2015	1969	1979	2000	2015
Brazil	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
North	2.2	3.2	4.6	5.4	1.0	2.0	4.6	6.3
Northeast	11.7	12.0	13.1	14.2	5.9	7.4	8.9	10.4
Southeast	65.5	62.4	57.8	54.0	80.8	73.4	65.8	58.1
Minas Gerais	8.3	9.4	9.6	8.7	7.6	8.1	9.5	10.2
Espírito Santo	1.2	1.5	2.0	2.0	0.4	1.0	2.0	2.9
Rio de Janeiro*	16.7	13.8	12.5	11.0	16.3	11.2	9.5	10.7
São Paulo	39.4	37.7	33.7	32.4	56.4	53.0	44.8	34.3
South	16.7	17.0	17.6	16.8	11.7	15.3	18.5	19.8
Central-West	3.9	5.4	7.0	9.7	0.7	1.3	2.2	5.5

Source: GDP - 1970, 1980, 2000: IBGE, Directorate of Research, Coordination of National Accounts;2015: IBGE, Regional Accounts. VIT: IBGE, Annual Industrial Research, Companies.

*In 1969 and 1970, the state of Guanabara is included.

THE CHALLENGES OF INDUSTRIAL AND REGIONAL POLICIES

Overcoming the relative backwardness of Brazilian industry and the processes of deindustrialization and denationalization requires a permanent and enduring effort of a new industrial policy. First, because, as Laplane (2015) demonstrates, industry is still the driving force of growth, especially in its contribution to innovation itself and to other sectors of the economy and their importance in international trade. Second, due to the potential that Brazil still holds, the size of its internal market, its territorial size and regional diversity, and the previously built production base.

In recent years, a great effort has been made to expand and modernize the industrial sector. However, this was achieved in a paradoxical conflict with the macroeconomic policy, which has reduced or even nullified the industrial, scientific and technological policies. Despite this, there has been a relative process of industrial deconcentration, as the data in Table 2 indicate.

The advancement of the agricultural and mineral frontiers and the consequent increase in the demand for industrial inputs and consumer goods, along with income transfer policies, improvement of physical infrastructure and human resources, fiscal incentives, availability of financing through of public agencies (BNDES, FINEP, BB, BNB, BASA) and political decisions have stimulated and facilitated the industrial deconcentration process.

On the other hand, considering the recent progress in the process of economic and industrial deconcentration, the need to maintain and expand these trends and the risk of their commitment to the effects of technological modernization and productive restructuring, then economic policy in general and industrial policy in particular, need to include explicit guidelines for the industrial deconcentration process to continue.

Considering the accumulated experiences, the different diagnoses regarding

the situation of Brazilian industry and the different agenda proposals, analyzed and systematized in several documents, we understand that the country is prepared for the reconstruction of its industrial policy and of its central branch, represented by the policy for science, technology and innovation. However, the success of such a proposal requires the definition of a national development plan, reconciling and coordinating the macro (especially exchange, interest and taxes), sectoral and thematic dimensions, and the different institutions and governing bodies.

Inspired by the knowledge of these different attempts and by the current world experiences, in July 2014, the Brazilian Government launched the *Programa Nacional de Plataformas do Conhecimento* (National Program of Knowledge Platforms) (Decree, 8.269/2014). The program proposed the creation of up to twenty knowledge platforms over a period of 10 years. The idea would be the constitution of public-private arrangements with a joint assembly of each platform by companies, public institutions supporting science and technology (represented by CAPES and CNPQ) and public institutions for development and financing (with emphasis on BNDES and FINEP), linked with state institutions so as to promote research and funding.

It is believed that this would be a fundamental manner in which to combine the processes of innovation with industrial growth, with the use of regional potentialities and with the process of industrial and economic deconcentration.

Political changes, after the departure of President Dilma, have paralyzed the program. There remains, however, an expectation that they may be resumed at some point, although the race against time makes it difficult for the enterprise to be viable, at a time of rapid change in the global scientific and technological scenario.

These are the basic points for industrial and foreign trade policies that would be capable of promoting industrial growth with diversification and productive integration, productivity gains and competitiveness and, therefore, with the capacity to compete on the international markets and, consequently, to improve the position of the Brazil within the global scenario. To do this, the country needs to define a medium- and long-term project, guided by a planning system that defines objectives, goals and means and is coordinated, monitored and adjusted according to the general changes and their adaptability. In addition, it must induce the private sector, national and foreign, towards innovation, in much the same manner as countries that are at the frontier of the science, technology and innovation race.

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