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Sectoral deindustrialization and long-run stagnation of Brazilian manufacturing

Desindustrialização setorial e estagnação de longo prazo do setor manufatureiro brasileiro

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RESUMO: No Brasil e em outras partes do mundo, os diagnósticos de desindustrialização estão concentrados na manufatura agregada, de modo que as políticas podem ser ineficazes se a desindustrialização tiver um componente específico para o setor. Este estudo quantifica e analisa a desindustrialização para os subsetores individualizados da manufatura. Para tanto, foram criadas séries inéditas da participação dos subsetores da indústria no PIB brasileiro de 1970 a 2016, com base em dados oficiais do IBGE. Os resultados mostram que os subsetores da manufatura têm se desindustrializado em diferentes intensidades e períodos de manufatura agregada, e uma abordagem subsetorial revela traços ignorados pela literatura sobre a qualidade da desindustrialização. Concluímos que a desindustrialização brasileira é normal (e esperada) para os subsetores manufatureiros intensivos em mão de obra, mas prematura (e indesejável) para os subsetores intensivos em tecnologia. Portanto, a desindustrialização brasileira tem consequências negativas para o futuro desenvolvimento científico e tecnológico do país.
PALAVRAS-CHAVE: Desindustrialização setorial; desenvolvimento industrial; heterogeneidade setorial; mudança estrutural.

ABSTRACT: In Brazil and elsewhere in the world, diagnoses of deindustrialization are concentrated in aggregate manufacturing, so policies can be ineffective if deindustrialization has a sector-specific component. This study quantifies and analyses deindustrialization for the individualised manufacturing sub-sectors. To do this, unpublished series of the manufacturing sub-sectors' share in the Brazilian GDP from 1970 to 2016 were created, based on official IBGE data. The results show that the manufacturing sub-sectors have

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deindustrialised at different intensities and periods of aggregate manufacturing, and a sub-sectoral approach reveals traces ignored by the literature on the quality of deindustrialization. We conclude that the Brazilian deindustrialization is normal (and expected) for the labour-intensive manufacturing sub-sectors, but premature (and undesirable) for the technology-intensive sub-sectors. Therefore, Brazilian deindustrialization has negative consequences for the country's future scientific and technological development.
KEYWORDS: Sectoral deindustrialization; industrial development; sectoral heterogeneity; structural change.
JEL Classification: O14; L6; L16.

1. INTRODUCTION

From 1981 to 2018, Brazil had low growth, lower than the world growth rate, and even lower than the average of developing countries. In the same period, the country underwent a quick and intense process of deindustrialization (Palma, 2005; Bonelli, Pessôa, 2010; Cano, 2012; Nassif, Bresser-Pereira, Feijó, 2017; Morceiro, 2021). One element of empirical evidence is the significant reduction in the manufacturing value added (MVA) of the gross domestic product (GDP) in current basic prices, from 24.5% to 11.3% from 1980 to 2018.[1] Brazil started to deindustrialise while having a level of income per capita much lower than what was registered by the currently developed countries during their respective periods of deindustrialization.[2] During this process, service activities increased their weight, especially informal and low-productivity activities. For this reason, the literature has classified Brazilian deindustrialization as premature (Palma, 2005; Cano, 2012; Nassif, Bresser-Pereira, Feijó, 2017) and undesired, because it limits economic growth potential (UNIDO, 2015).

The loss of dynamism of the manufacturing sector raises concerns because this sector is quite relevant in the production of technological innovations, the creation of trade surpluses, the stimulation of economic growth, the elevation of the productivity of the economy, and the promotion of regional development (Kaldor, 1966; Manyika et al., 2012; Rodrik, 2007, 2016; Moretti, 2010; Szirmal; Verspagen, 2015; UNIDO, 2015). Therefore, the manufacturing sector acts as an engine of econom-

[1] In constant 2018 prices, the MVA/GDP reduced from 19.7% to 11.3%, according to the authors' calculations and based on the various editions of the National Accounts of the Brazilian Institute of Geography and Statistics (IBGE).

[2] Normally, the manufacturing sector starts to lose GDP share in an intermediary phase of development (Herrendorf, Rogerson, Valentinyi, 2014) when income per capita reaches US$ 20.0 thousand in parity purchase power (PPP) of 2016, according to monetary updated estimates from Rodrik (2016). In 1981, when Brazil started to deindustrialise, its income per capita was US$ 10.8 thousand in 2016 PPP; in other words, a much lower level than the one estimated by Rodrik (2016). In 2017, Brazil's per capita income was $ 15.0 thousand in PPP, which is still below the Rodrik (2016) estimate. Values in PPP from The Conference Board (2017).

ic growth (Kaldor, 1966; Thirlwall, 2002; Haraguchi, Cheng, Smeets, 2017), or as an escalator-sector to stimulate economies, mainly undeveloped, to achieve a high degree of development (Rodrik, 2013, 2014). In many ways, contemporary society is a product of industrialization (Rodrik, 2016, p. 1). Many highly developed countries became developed and attained a high income per capita during their respective periods of industrialization. When manufacturing loses much weight in the economy, the growth engine reduces its power, resulting in lower growth rates.

Due to the importance of the manufacturing sector, some Brazilian authors have defended reindustrialization policies (Nassif, Bresser-Pereira, Feijó, 2017).[3]

Current deindustrialization diagnoses and policy propositions concentrate on aggregate manufacturing; in other words, they consider the sector as a unit, overlooking significant heterogeneities within the manufacturing sector. Manufacturing sub-sectors, however, diverge in terms of i) technology (Breschi, Malerba, 1997; Galindo-Rueda, Verger, 2016), either in the production or use of innovations (Hauknes, Knell 2009); ii) income elasticity of demand (Haraguchi, 2016; UNIDO, 2015); iii) dynamism in international trade (Lall, 2000); iv) intersectoral linkages (Hirschman, 1958); v) inputs used in the productive process (IBGE, 2016a); vi) intensity in capital; vii) intensity in qualified and unqualified labour; viii) degree of assembly; ix) degree of commercialisation in relation to foreign countries; and x) sensitivity to exchange rate. Therefore, the deindustrialization indicators can go through distinctive variations between the manufacturing sub-sectors, but not necessarily in the same direction as the aggregate manufacturing, thereby jeopardising the effectiveness of policies based on diagnostics with manufacturing being treated in a homogenous way. Besides, there are different consequences if deindustrialization concentrates on sub-sectors intensive in science and technology, or sub-sectors intensive in unqualified work. In this sense, the manufacturing sector's composition of a deindustrialized economy matters qualitatively for future development.

Brazilian authors have extensively reviewed Brazilian deindustrialization (e.g., Hiratuka, Sarti, 2017; Morceiro, 2012). However, some questions remain open. In the last decades, did all sub-sectors of Brazilian manufacturing lose GDP participation? Or was the dwindling concentrated sub-sectorally? Are there any sub-sectors in which deindustrialization did not happen? Did the manufacturing sub-sectors deindustrialise in the same period as aggregate manufacturing? Are the more deindustrialized sub-sectors of high or low technological intensity? This study tries to answer questions like these.

In this investigation, we had as our objective to quantify and analyse if Brazilian deindustrialization was general or concentrated sub-sectorally; in other words, if distinctive behaviours of the aggregate manufacturing happened at the sub-sectoral level. This study also sought to point out which manufacturing sub-sectors follow

[3] Even highly developed regions, such as the European Union and the United States, have defended reindustrialisation and industrial revitalisation policies (European Commission, 2012, 2013; Executive Office of the President of the United States, 2012).

a normal trajectory or premature deindustrialization, considering the Brazilian development stage.

For this reason, we created a new time series concerning the participation of manufacturing sub-sectors in the Brazilian GDP from 1970 to 2016, and the real evolution of value-added manufacturing sub-sectors since 1980. To create these time series, the authors used sub-sectoral data from the Consolidated Accounts for the Nation (IBGE, 1994, 1996, 2006), from the System of National Accounts Reference 1985 (IBGE, 2004) and from the System of National Accounts Reference 2010 (IBGE, 2018). In this way, we used official national accounts that adopted the same methodology for specific periods to create a sub-sectoral long-run time series.

This study is innovative because it presents a sectoral approach to deindustrialization from the view of GDP. This is absent from the deindustrialization literature, had here allows us to evaluate the quality of deindustrialization and provide more detailed information to policymakers and interested agents.

Besides this introduction, the study has four additional sections. Section 2 describes the data sources and methodological proceedings. Section 3 evaluates aggregate (de)industrialization with data for the last seven decades. Section 4 exhibits sub-sectoral series constructed from 1970 to 2016, allowing a sub-sectoral evaluation of Brazilian deindustrialization since its beginning. We conclude our study in section 5.

2. SOURCES OF DATA AND METHODOLOGICAL PROCEDURES

2.1. Data

The data on gross value added (GVA) – which is equivalent to the GDP measure in basic prices or factor cost – for the Brazilian manufacturing sub-sectors come from three different national accounts that existed in specific periods and had the same mensuration methodology as the IBGE. From 1971 to 1991, we used data from IBGE (1994, 1996, 2006); from 1992 to 2000, we used data from IBGE (2004); and from 2001 to 2016 we used data from IBGE (2018). In this way, we had homogenous national accounts – in other words accounts that used the same methodology – to construct and examine the participation of manufacturing sub-sectors in the GDP and the real evolution of manufacturing sub-sectors' value-added from 1980 to 2016.

2.2. Sectoral aggregation and technological categories

The three national accounts used in this study adopted different methods of sub-sectoral aggregation. The Consolidated Accounts for the Nation – Reference 1980 (CCN Ref. 1980) has data for 36 sub-sectors of the economy; the National Accounts System – Reference 1985 (SCN Ref. 1985) has data for 43 sub-sectors; and the National Accounts System – Reference 2010 (SCN Ref. 2010) for 51 sub-sectors.

As shown in the Appendix, the manufacturing sub-sectors were well represented in each of the three national accounts systems.

This paper adopts a sub-sectoral aggregation for 13 comparable manufacturing sub-sectors from 1970 to 2016. When making this aggregation, we sought to follow criteria such as (i) disaggregate the most sub-sectors possible and (ii) keep the same basis of sub-sectoral comparison throughout the period. In the end, we reached 13 individual sub-sectors following these criteria (see Appendix).

The 13 sub-sectors were divided into two groups according to their technological intensity, whether it was high or low. The first group includes categories of high and medium-high technology in terms of the classification of technological intensity adopted by the OECD, besides petroleum refining and alcohol. The second group includes the categories of low and medium-low technology adopted by the OECD, except petroleum refining and alcohol.[4] The choice of only two technological categories happened because there is a lower variability of technological sub-sectoral intensities in Brazil than in the OECD countries. The Appendix shows both technological groups.

2.3. Pricing and linking of the series

To construct the series at constant 2016 prices from the 13 manufacturing sub--sectors, we used the annual volume variation of the gross value added (GVA) – or variation of the real product – to each sub-sector applied in the 2016 GDP sub--sectoral composition.

The following equation was used to obtain the sub-sectoral share in the GDP:

$$P_i = \left(\frac{S_i}{GDP} \right) 100 \qquad (1)$$

in which S_i is the gross value added of the manufacturing sub-sector i measured in constant and basic 2016 prices, with i representing each one of the 13 manufacturing sub-sectors. GDP is the gross national product valued at basic and constant 2016 prices. P_i is the share of the manufacturing sub-sector i in GDP, measured in percentage, at basic and constant 2016 prices.

In this way, the sub-sectoral share of GDP was measured at basic and constant 2016 prices. The sub-sectoral variation in real terms used in each period was: 1971 to 1991 from CCN Ref. 1980; 1992 to 2000 from SCN Ref. 1985; and 2001 to 2016 from SCN Ref. 2010.[5] We also used the real variation of these periods to the

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[4] Thus, the category of higher technological intensity includes the divisions 19 to 21 and 26 to 30, and the lower technological intensity includes the divisions 10 to 18, 22 to 25, and 31 to 33, both at ISIC 4. (International Standart Industrial Classification). For the 1980s data, it was not possible to separate the petroleum refining and alcohol sub-sectors from the chemicals sub-sector. For that reason, the petroleum refining and alcohol sub-sectors were kept in the higher technological intensity category from 1970 to 2016.

[5] The GVA of the CCN is valued according to factor costs, while SCN Ref. 1985 and Ref. 2010 are valued at basic prices.

aggregate of the economy, in other words, to the GDP at basic prices. However, a few sub-sectors – namely "furniture, wood and diverse products", "leather and skins", "editorial and printing" – did not have real variation in the CCN ref. 1980 for the period 1971 to 1991, as well as the pharmaceuticals sub-sector from 1971 to 1976. The real variation in these sub-sectors was estimated using the data from employees linked to the industrial production of the Annual Industrial Survey and the Census (1970, 1975 and 1980), which are methodologically standardised by the IBGE (1990, p. 395) for annual comparisons from 1970 to 1984, and by the "yearly employee indexes linked to industrial production, according to the sectors and sub-sectors of the industry – 1972-2000", made available by IBGE (2006).

The sub-sectoral share of GDP from 1970 to 2016 is properly analysed in the fourth section of this article. We should emphasise that the sub-sectoral series are valued at constant 2016 prices. In this way, it was possible to evaluate structural changes without the interference of relative prices, considering that the sub-sectoral inflation was eliminated when we used the real variation of GVA in each sub-sector.[6]

For the real evolution of the sub-sectoral GVA, we used the same real variations in the mentioned periods in the second to last paragraph, with 1980 as the basis year equal to 1.0 (see section 4). We adopted 1980 as the basis year because the manufacturing sector started to grow more slowly than the aggregate economy from 1981.

In the next section, we see the times series of relative and absolute (de)industrialization of the Brazilian economy for the last seven decades from the perspective of aggregate manufacturing.

3. AGGREGATE APPROACH TO (DE)INDUSTRIALIZATION IN THE LAST SEVEN DECADES

The industrialization of Brazil progressed until 1980, when the absent sub-sectors were included in the domestic production matrix and the manufacturing sector got the highest growth rates, especially from the 1950s. The light and non-durable consumer industries were installed before the Second World War. After the war, sub-sectors of heavy industry and capital-intensive were established as intermediate goods, durable consumer goods, and capital goods. Graph 1 shows the degree of industrialization – the manufacturing value added (MVA) divided by the gross domestic product (GDP) at basic and constant 2018 prices – for the last seven decades, capturing the periods of intense industrialization of the Plano de Metas (Plan of Aims, 1956 to 1961), the Economic Miracle (1968 to1973) and the Second National Development Plan (2nd NDP, 1975 to 1980).

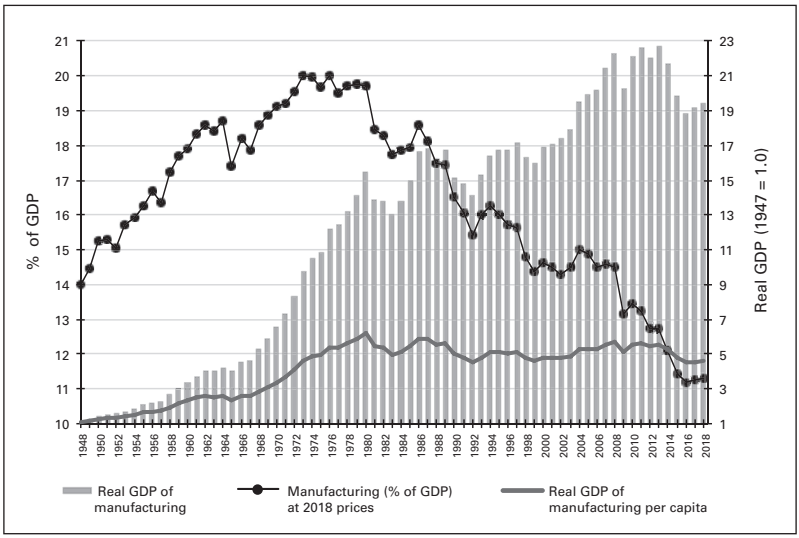
The share of the MVA in the GDP at constant prices (instead of current prices) is an adequate indicator to study (de)industrialization because it captures the ca-

[6] This procedure dispenses with the use of sub-sectoral deflators.

pacity of manufactures to influence the growth of the rest of the economy. In this work, the analysis will concentrate on constant prices' degree of industrialization, because the indicator at the current price is contaminated by the inflation of subsectors, especially in periods of exchange rate variation and trade opening (which modify the relative prices).

The degree of industrialization and real manufacturing GDP increased most during intense industrialization (Graph 1). Between 1967 and 1980, the real GDP of manufacturing more than tripled. The peak of the degree of industrialization happened in 1973, and it maintained this position until 1980, when manufacturing was almost 20% of the GDP. Brazilian manufacturing was the main engine of economic growth until 1973. Between 1974 and 1980, MVA grew at the same rate as the total economy, even though the real manufacturing product had expanded significantly due to the implementation of the 2nd NDP. The maintenance of the degree of industrialization at around 20% at constant prices in the second half of the 1970s sustains the affirmation of Castro (1985)'s forced march industrialization. If it was not for the 2nd NDP, deindustrialization probably would have begun in the second half of the 1970s.

Graph 1: Real GDP of manufacturing sector and degree of industrialization, 1948-2018



Note: GDP at basic prices. Real variations by sector for the series at constant prices and for the evolution of real GDP.
Source: IBGE (1994, 1996, 2004, 2006, 2013, 2016b, 2019). Authors' calculations and elaboration.

The peak of Brazilian industrialization was in 1980. Until this year, the real manufacturing product grew at elevated rates, but it reversed the tendency from 1981, as shown in Graph 1. Besides, during the 2nd NDP, industrial segments relevant to the production matrix of the country were implemented and expanded, especially

of intermediate goods (non-ferrous metallurgy, chemicals, petrochemicals, fertilisers, paper and cellulose, steel, and cement) and capital goods (transport equipment, machinery and equipment, electric and communication equipment). The industrialization until 1980 implemented absent sub-sectors and their productive upstream chain.[7] Thus, Brazil started to manufacture intermediary inputs and products of practically all available segments of the mature industrialized countries. However, it did not produce them with the same efficiency because the national industry was too protected;[8] there was weak technological development[9] and a low export coefficient[10] (Suzigan, 1988, pp. 9-10).[11] The exporting performance and creation of technology by the Brazilian industry were too low compared to the mature industrialized countries (the United States, Japan and Germany).

It is worth mentioning that relative to developed countries, the duration of industrialization at its peak was short in Brazil, lasting only eight years (1973 to 1980), while in the United States it was at least 20 years (1947 to 1966). The latter is based on data from the American GDP and employment (which have data starting in 1947 and 1929 respectively). The American manufacturing sector remained at its peak of 26.2% of GDP from 1947 to 1966 (average 20 years) and 29.1% of total employment from 1929 to 1969 (average 41 years), according to data from the U.S. Bureau of Economic Analysis. With the intensification of industrialization, the income per capita increased significantly, and the United States escaped from the middle-income trap, unlike Brazil.

From 1981 to the present, Brazil has regressed in its industrialization trajectory, mainly because the manufacturing sector stopped being the growth engine. This can be observed in the stagnation of the real manufacturing product and the significant fall in the degree of industrialization (Graph 1). Since 1981, there has been a decreasing tendency in the degree of industrialization, which diminished from 19.7% to 11.3% between 1980 and 2018 (Graph 1).

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[7] In the 2nd NDP, "the objective was to complete the Brazilian industrial structure and create the capacity of exporting some basic inputs" (Suzigan, 1988, p. 9, translated). Ending the 2nd NDP, "the industry of this country [...] had its structural deficiencies literally overcame" (Castro, 1985, p. 83, translated).

[8] Brazilian industrialization happened with the strong support of the state (Suzigan, 1988), which imposed high tariffs on tradeable and non-tradeable products, devalued the exchange rate, local content requirements, and there was an absence of performance counterparts (export and technology) and deadlines (Suzigan, 1988). These measures restricted imports. Consequently, imports accounted for only 5.8% of the supply of industrial products in 1980 (Ramos, 1999, p. 18).

[9] "Up to the 1970s, little original technology was created in Brazil" (Baer, 1985, p. 313, translated). Such a scenario has not changed much until recent days (Tessarin, Suzigan, Guilhoto, 2020).

[10] In 1980, the export coefficient of the manufacturing sector was only 7.3% (Ramos, 1999, p. 18).

[11] "In fact, the industrialization policies implemented since the 1950s were predominantly defensive and were characterised by an exaggerate and permanent protectionism. Along with exchange rate policy, these policies favoured more elevated return rates in the internal market than in exportation, thus giving rise to a tendency to produce for the domestic market. The result was the development of an industry with a high degree of inefficiency, that therefore was not competitive internally or internationally, with little or no creativity in technological terms" (Suzigan, 1988, p. 10, translated).

As the graph shows, there were *two periods of intense deindustrialization*. The *first* was from 1981 to 1999, and started with an external debt crisis, intermediated by trade opening that substantially removed the protectionist policies and ended with industrial restructuring in an environment with an overvalued exchange rate and elevated interest rate. We emphasise that the Brazilian economy went through two recessions, one in the triennium 1981 to 1983, and the other in the triennium 1990 to 1992; in both, the real MVA retracted at a rate slightly higher than 15%. In the 1980s, there was a significant reduction of public investment in infrastructure and state-owned enterprises (Carneiro, 2002; Suzigan, 1992), which encouraged Brazilian industrialization in the earlier periods. Import tariffs started to be reduced in 1988 and were reduced sharply until 1992, and the main non-tariff barriers were removed in 1990 (Kume, Piani, Souza, 2003). Furthermore, the country started to deal with irregular and chronic inflation from 1987, which slowed down investment decisions (Bielschowsky, 1999). These factors – added to the harmful effects of the failed stabilisation plans on the expectations and industrial park's adjustments to the trade opening in a period in which an overvalued exchange rate – contributed to deepening deindustrialization in this first period.

The *second period of intense deindustrialization* started in 2009 and is still ongoing. It started with the subprime crisis – which gained an international dimension in September 2008 with the bankruptcy of Lehman Brothers – and had immediate effects on international trade and investment decisions. It continued with the exceptional politico-economic instability of the Brazilian economy after the election in 2014, which culminated in the impeachment of President Dilma Rousseff and in the uncertainty about the new president's policies.

The real manufacturing GDP stagnated during the 1980s and 1990s, returning to grow continually in the 2000s, and this advance remained until 2008 (Graph 1). We can observe that both periods of intense deindustrialization were intermediated by the stability of manufacturing share in the GDP at constant prices between 2000 and 2008, even with the significant increase in the real manufacturing GDP until 2008 (Graph 1). Thus, even in the period of most significant industrial growth since the 1970s – when domestic demand for manufactured products grew above the total demand (Morceiro, 2018) – the share of manufacturing in GDP at constant prices remained stable at around 15% between 2000 and 2008 (Graph 1). Therefore, policies that only stimulate aggregate demand may not be enough to reindustrialize the country.

An international comparison highlights that Brazil is falling behind. Between 1980 and 2015, Brazil's real manufacturing product expanded by only 28%, while the United States and the "World without China" increased at a rate four times greater and the world six times greater (Table 1). Therefore, Brazil is increasingly distancing itself from the leading countries. It is noteworthy that the real manufacturing product per capita in Brazil is stagnant and has had a downward trend since 1980; in 2018 it was 25.8% lower than the level obtained in 1980 (Graph 1).

The international literature has identified "normal" deindustrialization only when MVA in the GDP is measured at current prices due to changes in relative prices

(Rodrik, 2016; Singh, 1987). A recent study shows that manufacturing inflation has grown at a much lower rate than the rest of the economy, especially since the 1970s (Herrendorf, Rogerson, Valentinyi, 2013, p. 2759). This happens because the growth in productivity is higher in manufacturing than in the rest of the economy, especially concerning the services sector, and that services, in their majority, have a lower degree of commercialisation than manufactured products with foreign countries, as shown by Baumol (1967). Therefore, on the one hand, manufacturing can manage better increases in prices due to the growth of price-reducing productivity and, on the other, the competitive pressure in international trade imposes a limit on price transmission to the consumer; services, however, have less influence from these two transmission channels.

However, there is no deindustrialization in the global economy at current prices (Felipe, Mehta, 2016). From 1970 to 2010, these authors verified that the fall of manufacturing in the global GDP remained stable, at 16%, at 2005 prices. At constant prices, the developing countries' aggregate presented a tendency to industrialization from 1970 to 2013 (Haraguchi, Cheng, Smeets, 2017). Moreover, at current prices, if we exclude the split or unified countries, the aggregate of developing countries does not present a deindustrialization tendency in the same period (Haraguchi, Cheng, Smeets, 2017). Brazil presents a clear tendency to deindustrialization at both constant prices and current prices, as Graph 1 shows. Nevertheless, how much does Brazil differ from the global economy?

Table 1: Manufacturing value added (MVA) and degree of industrialization, 1980-2015

	World			World w/o China			United States			Brazil		
	1980	2015	Δ%	1980	2015	Δ%	1980	2015	Δ%	1980	2015	Δ%
MVA / GDP (in %), current prices	23.2	16.5	**-29**	23.1	14.6	**-37**	20.6	12.0	**-42**	24.5	12.2	**-50**
MVA / GDP (in %), 2005 constant prices	16.3	18.0	10	16.2	16.1	**-1**	12.4	12.6	2	23.0	13.3	**-42**
Real MVA (1980 = 1,00)	1.00	2.75	175	1.00	2.24	124	1.00	2.26	126	1.00	1.28	28

Source: United Nations, World Bank, IBGE (1994, 1996, 2004, 2019). Elaborated by the authors.

Table 1 shows the degree of industrialization and the real manufacturing product evolution between 1980 and 2015, the period of Brazilian deindustrialization, and a comparison with the United States, the world, and the world without China. The United States is a country of mature industrialization and is a leader in technological development. China has become industrialized rapidly in the last decades, and it is currently the largest industrial park in the world (UNIDO, 2017), and we created the rubric World without China to capture world deindustrialization without the influence of this country.

Brazilian deindustrialization was much more active than that observed in the regions in Table 1, both at current and constant prices. At current prices, the MVA

in the GDP diminished for the analysed regions, conforming with the mentioned literature, but the reduction in Brazil was intense. At constant prices, the world and the United States increased their degree of industrialization, by 10% and 2% respectively, between 1980 and 2015 (Table 1). Using data from the United Nations, it is also possible to verify that there was an increase in the degree of industrialization at constant prices in some developed countries besides the United States – such as Japan, South Korea, Sweden, Ireland, and Switzerland – and in many developing countries, such as China, India, Indonesia, Turkey, Thailand, Poland and Saudi Arabia. If we consider the deindustrialization of the world without China as *normal* due to factors that affect all countries (such as globalisation), the Brazilian deindustrialization is quite abnormal, since the MVA part in the GDP of the 'World without China', at constant prices, reduced by only 1%, while the reduction in Brazil was 42% between 1980 and 2015 (Table 1).

In summary, the degree of Brazilian industrialization has diminished significantly since 1981, especially in periods of intense deindustrialization. However, this diagnosis treats the manufacturing sector as an aggregate unit, thus the manufacturing sub-sectors are considered homogenous. The next section verifies if the manufacturing sub-sectors follow deindustrialization trajectories different from aggregate manufacturing.

4. SUB-SECTORIAL SERIES AND EVOLUTION OF BRAZILIAN DEINDUSTRIALIZATION

4.1. Long-run sub-sectoral de industrialization analysed by the GDP

There is an empirical regularity that expresses the share of manufacturing in the GDP and the income per capita in the shape of an inverted U curve (Herrendorf; Rogerson; Valentinyi, 2014; Palma, 2005). At lower and intermediary levels of income per capita, the share of manufacturing tends to increase (industrialization phase), and in the passage to elevated levels of income per capita, manufacturing tends to lower its weight in the GDP (deindustrialization phase). In the change of phase, the income per capita reached around US$ 20.000 in 2016 PPP (at the inflection point of the inverted U curve), with manufacturing contributing around 25% of the GDP at current prices (Rodrik, 2016).[12]

It is expected that the manufacturing sub-sectors individually reach a peak in GDP at different levels of income per capita (or development stages), mainly due to the income effect, because as the income per capita increases, the composition

[12] In constant 2016 prices, deindustrialisation starts at high income per capita levels, above US$ 47 thousand in PPP. An econometric simulation obtained these levels with data from the late 1940s to 2011 for a sample of 42 developed and developing countries that are responsible for 75% of the world GDP. The level of income per capita in Rodrik (2016) was updated by the authors for 2016 data, using the consumer price index of the United States.

of the demand changes. At lower levels of income per capita, the familial budget goes to essential goods such as food, wearing apparel, footwear, and housing, and at higher levels it goes to items that are more income-elastic, such as vehicles, computers and tourism. Thus, it is expected that sub-sectors such as food, wearing apparel and footwear register their peak at lower income per capita than those that produce vehicles and computers.

There is empirical evidence for this effect. Haraguchi (2016) verifies how the share of manufacturing sub-sectors in the GDP changes in relation to the increase in per capita income. The author used panel data from a UNIDO database of 18 manufacturing sub-sectors from 1963 to 2010 for about one hundred countries. We emphasise that Haraguchi's study is not about deindustrialization, but we will use it – for the first time – to discuss this phenomenon due to the natural association with normal and premature deindustrialization. Haraguchi observes that the GDP peaked for each of the manufacturing sub-sectors and classified them into three development stages: initial, intermediary, and advanced (Table 2).

Table 2: Peak of the manufacturing sub-sectors in the GDP by degree of development

Development stage	GDP per capita in PPP 2016	Manufacturing sub-sectors that peaked in GDP
Initial	< US$ 8k	Food, beverages, and tobacco Textiles and wearing apparel Wood and Furniture Printing Non-metallic minerals
Intermediary	US$ 8k to US$ 18.5k	Coke and refined petroleum Paper Basic metals Fabricated metals
Advanced	> US$ 18.5k	Plastics and rubber Motor vehicles Chemicals Machinery and equipment Electrical equipment Computer, electronic and optical products

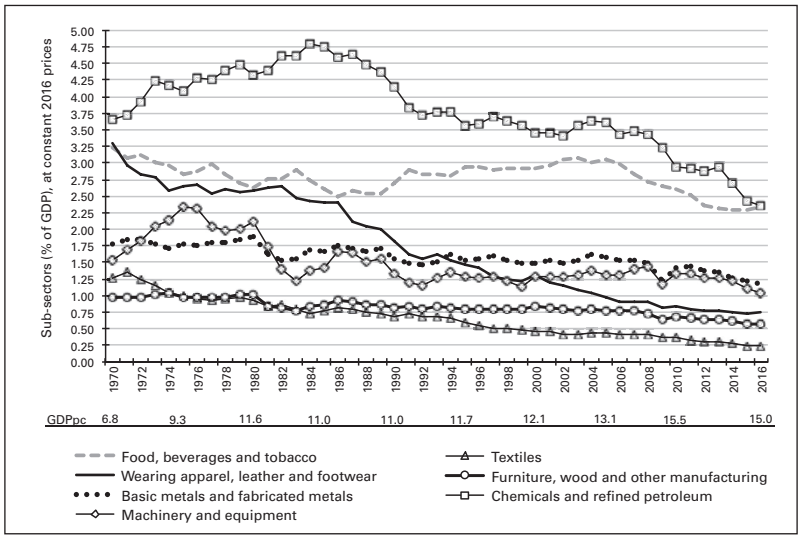
Note: Values in PPP updated by the authors using the CPI of the USA for 2016.
Source: Elaborated by the authors, based on Haraguchi (2016, p. 47).

In the *initial stage*, the industries intensive in labour and that produce essential products dominate the manufacturing sector and reach a participation peak in GDP. In the *intermediary stage*, the industries intensive in capital and that process natural resources to produce material inputs for other industries reach a participation peak in GDP and acquire a relevant share of the industrial product. Lastly, in the *advanced stage*, besides for rubber and plastic, the industries intensive in technology and knowledge that produce capital goods for firms and consumer goods for families reach their peak in GDP. In this last stage, countries successful in innova-

tion can obtain high growth rates in the manufacturing sub-sectors that are intensive in technology and knowledge. Thus, "[…] these industries will be important to avoid premature deindustrialization, to promote technological development and to generate employment in manufacturing, as well as related service industries, so that the manufacturing industry continues to contribute to a country's development" (Haraguchi, 2016, p. 47). In this way, each manufacturing sub-sector has its own inverted U-shaped curve and deindustrialises at different stages of development. The performance in sub-sectors intensive in technology and knowledge is vital to escape premature deindustrialization and, consequently, from the middle-income trap.

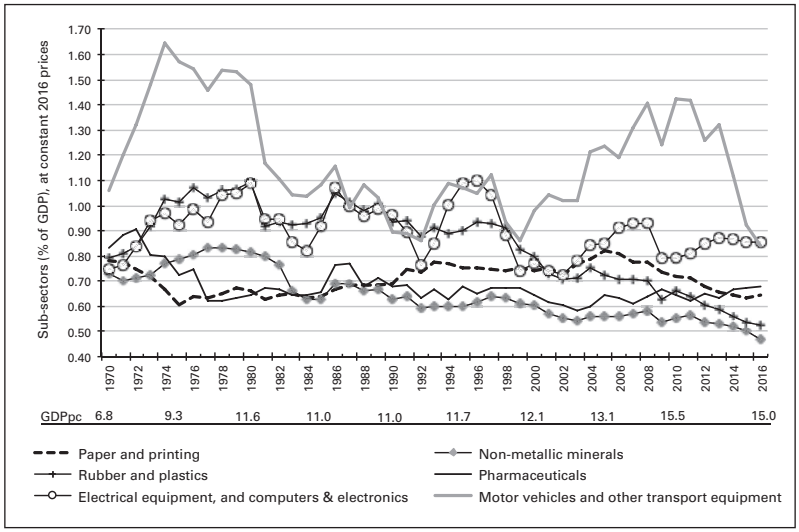
Graphs 2 and 3 show the participation of the manufacturing sub-sectors in the Brazilian GDP from 1970 to 2016. The following assessment of the shape of the sub-sectoral curves over time seeks to consider the observed pattern of sub-sectoral structural change, shown in Table 2, that relates the GDP's sub-sectoral share and income per capita level of the countries.

Graph 2: Sub-sectors that most reduced their share in GDP at 2016 prices, 1970-2016



Source: IBGE (1994, 1996, 2004, 2018) and The Conference Board (2017). Authors' calculations and elaboration.

Graph 3: Sub-sectors that least reduced the share in GDP at 2016 prices, 1970-2016



Source: IBGE (1994, 1996, 2004, 2018) and The Conference Board (2017). Authors' calculations and elaboration.

Brazil started to deindustrialise in the 1980s (Morceiro, 2021), when its income per capita reached 60% of the level estimated by Rodrik (2016). For this reason, the Brazilian deindustrialization is premature. However, can the deindustrialization be classified as premature for all manufacturing sub-sectors? Did all of them start to lose share in GDP at the same time and with the same intensity?

Graphs 2 and 3 present the manufacturing sub-sectors that have more and less reduced their share in GDP since 1970. Together, seven sub-sectors were responsible for more than 80% of the manufacturing share loss in GDP from 1970 to 2016 (Graph 2). Therefore, deindustrialization concentrated on a few sub-sectors.

Manufacturing sub-sectors began to lose their share of GDP in different years and at different paces from aggregate manufacturing (see Graphs 1, 2 and 3). Wearing apparel, leather and footwear, and the textile sub-sector started to lose share from the beginning of the 1970s; machinery and equipment from the middle of the 1970s; basic metals and fabricated metals, and non-metallic minerals from the beginning of the 1980s; chemicals and refined petroleum from the middle of the 1980s; and food, beverages and tobacco from the middle of the 2000s. Besides, only a few manufacturing sub-sectors, such as electrical equipment, computers & electronics, and paper and printing, did not present a tendency to deindustrialization. Therefore, Brazilian deindustrialization did not start in all sub-sectors at the same time.

Sub-sectoral deindustrialization is not homogenous in terms of its intensity. For example, wearing apparel, leather, and footwear registered much more intense deindustrialization than non-metallic minerals (see Graphs 2 and 3).

The lower part of each of Graphs 2 and 3 indicates the level in one thousand

dollars of Brazil's per capita GDP, using 2016 PPP, every five years. Between 1970 and 2016, Brazil's GDP per capita in PPP increased from US$ 6.8k to US$ 15k – levels of income per capita that correspond to the interval between the beginning and most of the intermediary stage of development of Haraguchi (2016). Therefore, we expected that

1. the manufacturing labour-intensive sub-sectors and suppliers of basic needs lowered their share of GDP because they should have reached their peak by then;
2. the capital-intensive sub-sectors and those that process natural resources to produce material inputs to other industries reach their GDP peak in the intermediary stage; and
3. the manufacturing sub-sectors intensive in technology and knowledge are still on an expanding trajectory of industrialization and have actively increased their share in GDP.

Brazil has followed the pattern observed of sub-sectoral structural change typical of the initial development stage (see Table 2), such as wearing apparel, leather, and footwear; textiles; non-metallic minerals; and furniture and wood products (Graph 2). The mentioned sub-sectors lost a lot of shares of GDP at the end of the initial stage and at the beginning of the intermediary stage, while the sub-sectors of food and beverages diverged from the expected pattern and only started to present a clear diminution tendency in the middle of the 2000s when the income per capita reached about US$ 13k in 2016 PPP (Graph 3). Since Brazil has one of the worst income distributions globally, food and beverages still have an elevated weight in the budget of low-income families.

Therefore, Brazil does not follow the pattern observed in relation to structural change in the sub-sectors of the advanced stage of development. Rubber and plastics and other sub-sectors intensive in technology and knowledge – machinery and equipment; chemicals and refined petroleum; and motor vehicles and other transport equipment – started to deindustrialise at a lower threshold of income per capita of the intermediary stage. The others did not follow the robust industrialization trajectory expected from a country with intermediary income per capita, with examples such as pharmaceuticals, electrical equipment, and computers & electronics (Graph 3).

It is clear Brazil presents grave premature deindustrialization in a few sub-sectors of high and medium-high technology. The other technological sub-sectors presented a stable tendency of sectoral participation in GDP when they should have presented a strong tendency of industrialization according to the stages of development presented in Table 2. From the sub-sectoral point of view, the premature Brazilian deindustrialization happened mainly due to the performance of high-technology industries that grew less than expected for a country with intermediary income per capita.

Despite oscillation in some periods, electrical equipment, and computers & electronics have kept a low and stable share in the Brazilian GDP since the 1970s (Graph 3). When considering only computers, this sub-sector was responsible for only 0.5% of the Brazilian GDP in 2015 and 2016, measured in basic prices (IBGE, 2018), while in the United States it presented a three and a half times bigger share of GDP (according to data from the Bureau of Economic Analysis, U.S. Department of Commerce).[13] In 2015, Brazil contributed only half a percent of the global value added of this sub-sector, while China and the United States led with 25.7% and 22.9% of the world total respectively (UNIDO, 2017, p. 69). In the OECD countries, this sub-sector is responsible for high-technology goods and benefits from high investment in R&D (Galindo-Rueda, Verger, 2016) and, in China, it was used as a *ladder* for the ongoing Chinese industrialization. The computer sub-sector also gave strength to the Third Industrial Revolution and has an essential role in the ongoing Fourth Revolution, called Industry 4.0 (Kagermann, Wahlster, Helbig, 2013). This sub-sector has grown a lot in the last decades and has gained significant weigh in the industry and in international trade. Given this situation, the low weight of this sub-sector in the productive Brazilian structure and its stability in the GDP evince the relative failure of Brazilian industrial development since the 1980s. In addition, other technological sub-sectors also have a relatively low level of share in the Brazilian GDP compared to the leading developed countries.

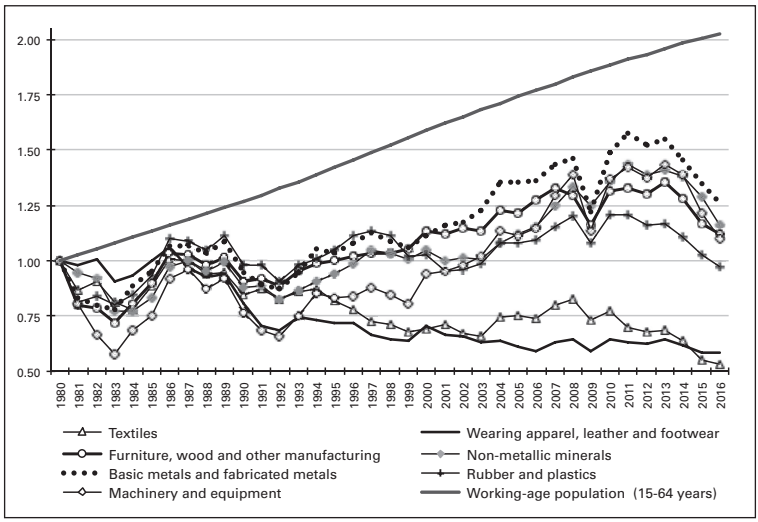
4.2. Long-run stagnation of Brazilian manufacturing sub-sectors

Graphs 4 and 5 show the accumulated growth in the manufacturing sub-sectors' gross value added since 1980. From this year on, the Brazilian manufacturing sector grew little. Between 1980 and 2016, except for pharmaceuticals, the other sub-sectors presented accumulated growth lower than the growth rate of the working-age population (WAP), indicating a real retraction of the sub-sectoral product per capita of the active population.

Sub-sectorally, the growth rates differed a lot. Graph 4 shows that the sub-sectors that presented mediocre growth, being the ones intensive in labour – namely textiles; wearing apparel, leather, and footwear; and rubber and plastics – had negative growth and, consequently, absolute deindustrialization.

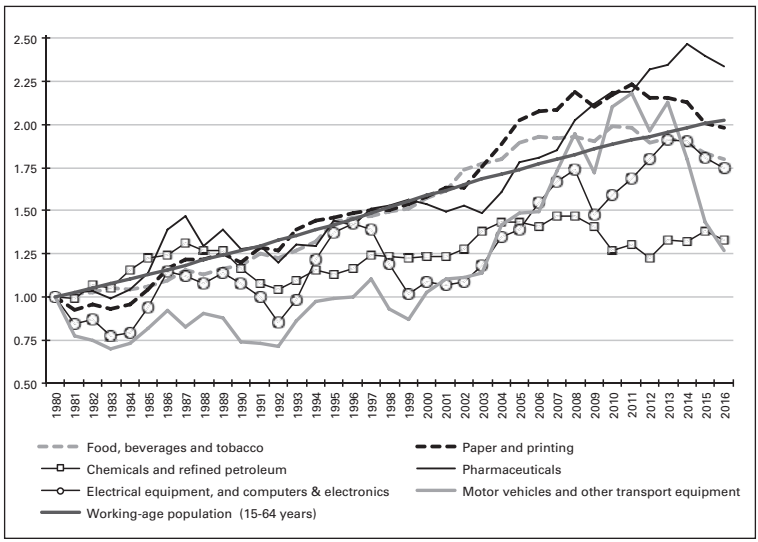
[13] In 2016, the manufacturing sector weight was identical in both Brazil and the United States, at 12% of GDP.

Graph 4: Real GVA of sub-sectors that grew below manufacturing, 1980-2016, 1980 = 1.0



Source: IBGE (1994, 1996, 2004, 2013, 2016b, 2018). Authors' calculations and elaboration.

Graph 5: Real GVA of sub-sectors that grew above manufacturing, 1980-2016, 1980 = 1.0



Source: IBGE (1994, 1996, 2004, 2013, 2016b, 2018). Authors' calculations and elaboration.

The sub-sectors in Graph 5 grew above the manufacturing sector – only pharmaceuticals grew slightly above the Brazilian GDP – and, in general, the sub-sectors with higher technological intensity grew more in the years 2000 to 2013, es-

pecially motor vehicles and other transport equipment, electrical equipment, and computers & electronics. Pharmaceuticals, food, beverages and tobacco, and paper and printing grew at the same rate as the WAP from the middle of the 2000s, with the former starting to grow above WAP and the second below (Graph 5). Pharmaceuticals were shown to be income-inelastic in Brazil because they are composed of essential products. Food, beverages and tobacco probably grew because two thirds of Brazilian families have a low income per capita and Brazil exports a lot of agro-industrial *commodities* with a low degree of processing (meat *in natura*, orange juice, raw sugar and soybean meal, for example). Paper grew thanks to the external demand.

Between 1980 and 2016, the MVA and GDP of Brazil presented accumulated growth, of 26.8% (or 0.66% annually) and 166.4% (or 2.17 annually) respectively, WAP doubled (see red line in Graphs 4 and 5) and, between 1980 and 2015, the economically active population over 15 grew even more – 119.9% (2.28% annually) – according to data from the National Survey by Family Sample (PNAD) of IBGE. These data indicate that the manufacturing sector annually grew three times slower than the WAP and the Brazilian GDP and, in this way, it lost weight in the GDP and did not follow the demographic tendencies. Consequently, there has been a *long-run retraction* in the Brazilian real manufacturing product, which reached practically all manufacturing sub-sectors and was more active in the sub-sectors shown in Graph 4.

Manufacturing stopped carrying the economic growth of the rest of the economy and came to present lower growth rates for the economically active population (and the total population) from the 1980s. Therefore, manufacturing contributed negatively to the real product per capita of Brazil. This situation differs from that in developed countries, where deindustrialization occurs *pari passu* with the increase in the real manufacturing product per capita.

5. CONCLUSION

Brazilian studies on deindustrialization concentrate their diagnosis and policy propositions on aggregate manufacturing and consider their products homogenously (Bonelli, Pessôa, 2010; Marconi, Rocha, 2012; Oreiro, Feijó, 2010; Palma, 2005), as well according to the international literature (Rodrik, 2016; Rowthorn, Ramaswamy, 1997, 1999; Singh, 1977; Tregenna, 2009). However, the data analysed in this article show that deindustrialization happens in a heterogeneous way *between manufacturing* sub-sectors, being *specific to the sub-sector*. This is our main contribution to the studies on the theme, including in the international literature, since the deindustrialization sub-sectoral approach is quite new.

Although the tendency to deindustrialization is present in many manufacturing sub-sectors, only a few explain the major role played by the diminution of the manufacturing in GDP. In this sense, deindustrialization is concentrated sub-sectorally.

Furthermore, we verified different performances *among* the manufacturing sub-

sectors. The ones intensive in labour and the suppliers of basic needs – especially wearing apparel, leather and footwear; textiles; furniture and wood; and non-metallic minerals – deindustrialized a lot; the first two since the 1970s and the last two since the 1980s. Deindustrialization in these sub-sectors is considered *normal* and is expected according to the observed pattern of sectoral structural change related to the sub-sectoral share in GDP and the countries' income per capita. However, it is *abnormal* and *premature* (concerning the same pattern) for a few manufacturing sub-sectors intensive in technology and knowledge, such as machinery and equipment, chemicals and refined petroleum, and motor vehicles and other transport equipment. These sub-sectors started to deindustrialise at levels of income per capita much lower than expected. Other sub-sectors intensive in technology and knowledge – pharmaceuticals, electrical equipment, and computers & electronics – did not follow a robust industrialization trajectory during the period from 1970 to 2016, which would be expected given the relatively low level of income per capita in Brazil. This premature case is problematic because the technological sub-sectors should be growing to reach a peak share of GDP at elevated levels of income per capita, from which Brazil is still far away.

Generally, the literature qualifies Brazilian deindustrialization as premature (Cano, 2012; Marconi, Rocha, 2012; Nassif, Bresser-Pereira, Feijó, 2017; Palma, 2005), but the empirical evidence we have presented allows us to organise Brazilian deindustrialization into three groups: the first gathers sub-sectors that presented a clear trajectory of *normal* deindustrialization; the second aggregates sub-sectors that presented a remarkable tendency to *premature* deindustrialization; and the third group includes a few sub-sectors that presented a clear tendency to neither industrialization nor deindustrialization. The last two groups include sub-sectors of higher technological intensity that should increase participation in the GDP and contribute to deaccelerating the intensity of deindustrialization in the aggregate Brazilian manufacturing.

In this way, the sub-*sectoral approach to deindustrialization* brings new evidence to the current debate, especially concerning the *quality* of deindustrialization, one that it is normal only for sub-sectors intensive in non-qualified labour and premature (and undesired) in sub-sectors intensive in science and technology, which are more income-elastic. Therefore, from a technological perspective, the premature structural change toward services, which have low technological intensity, has relevant implications for Brazil's future economic development.

Two factors can measure the *gravity* of Brazilian deindustrialization. First, the sub-sectors of higher intensity in technology have lost 40% of their participation in the GDP since 1980. These sub-sectors employ highly qualified workers and contribute proportionally more to technological development, besides using services intensive in knowledge and innovation in their production processes. In this sense, the ongoing deindustrialization has prematurely reached the *dynamic core* of Brazilian manufacturing. Second, the real GDP of most of the manufacturing sub-sectors, including manufacturing as an aggregate, grew less than the Brazilian population ever since the beginning of the aggregate deindustrialization in 1981. Therefore, there

is a *long-term retraction* of the real manufacturing product per capita and, consequently, a significant increase in the income per capita gap with developed countries. If we consider income per capita as a proxy of development, the Brazilian deindustrialization has contributed negatively to the country's development.

Policymakers should pay attention to not allowing deindustrialization to prematurely reach the *dynamic core* of manufacturing, and the sub-sectors that will have greater growth in domestic demand in the future.

Although proposing public policies does not fall within the scope of this study, the results obtained here support the use of industrial policies focused on manufacturing sub-sectors that still have a high possibility of expansion, given Brazil's income per capita. As mentioned at the beginning of this study, the manufacturing sub-sectors are heterogeneous concerning the production and use of technology, income-elasticity of demand, dynamism in international trade, and sensitivity to the exchange rate. Therefore, manufacturing (and its sub-sectors) deindustrialized at different periods and intensities, as shown in section 4. For this reason, there is a need for future policies to distinguish sub-sectors to attain greater effectiveness and not concentrate only on general macroeconomic policies, as defended by new-developmentalism (Bresser-Pereira, Oreiro, Marconi, 2015). Thus, the toolbox of policymakers can include many instruments and countermeasures that distinguish productive sub-sectors.

Policies can act in two directions: active and defensive. Active ones should encourage technology-intensive sub-sectors that will experience domestic demand in growth, given the intermediate level of Brazilian income per capita. These sub-sectors can slow down deindustrialization, allowing the income per capita to reach an elevated level. The defensive policies seek to diminish the intensity of the low-tech sub-sectors' normal deindustrialization, for example, by granting incentives for these sub-sectors to move to regions of lower wages. In this way, defensive policies would not add to the already high unemployment rate of the country.

The study also raises further questions. Would the explanatory factors for aggregate deindustrialization operate differently in the manufacturing sub-sectors? What are the consequences of deindustrialization when it reaches sub-sectors intensive in low-qualified labour or sub-sectors intensive in technology and qualified labour? Future studies could investigate the causes and consequences of deindustrialization at the sub-sectoral level of analysis.

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Appendix – Sub-Sectoral Aggregation from 1970 to 2016

		Aggregate 1970 to 2016	CCN Ref. 1980 – 36 sectors	SCN Ref. 1985 – 43 sectors	SCN Ref. 2010 – 51 sectors
MANUFACTURING	Lower technological intensity	Food, beverages and tobacco	Food Beverages Tobacco products	Manufacture of coffee Processing of vegetable-based products, including tobacco Processing and preserving of meat Manufacture of dairy products Manufacture of sugar Manufacture and refinement of vegetable oils and fat Manufacture of other food products and beverages	Food and beverages Tobacco products
		Textiles	Textiles	Textiles	Textiles
		Wearing apparel, leather and footwear	Wearing apparel and footwear Leather and related products	Wearing apparel	Wearing apparel
				Footwear, leather and related products	Footwear, leather and related products
		Furniture, wood and other manufacturing	Wood Furniture Other manufacturing	Sawmilling and manufacture of products of wood and furniture Other manufacturing	Furniture and other manufacturing
		Paper and printing	Paper and paper products Publishing and printing	Paper and printing	Paper and paper products Newspapers, magazines, and disks
		Non-metallic minerals	Non-metallic mineral products	Non-metallic minerals	Cement and other non-metallic mineral products
		Basic metals and fabricated metals	Basic metals and fabricated metals	Manufacture of steel Manufacture of basic precious and other non-ferrous metals Manufacture of other metallurgic products	Manufacture of steel and derivatives Manufacture of basic precious and other non-ferrous metals Fabricated metals, except machinery and equipment
		Rubber and plastics	Rubber Plastics products	Rubber Plastics products	Rubber and plastics
	Higher technological intensity	Chemicals and refined petroleum	Chemicals and chemical products	Refined petroleum products and petrochemicals Manufacture of non-petrochemical chemicals Manufacture of diverse chemicals	Refined petroleum products Manufacture of resin and elastomers Alcohol Chemical products Pesticides and other agrochemical products Paints, varnishes, enamel and lacquer Diverse chemical products
		Pharmaceuticals	Pharmaceuticals Perfumes, soaps, and candles	Manufacture of pharmaceutical and perfume items	Pharmaceutical products Perfumery, hygiene and cleaning
		Machinery and equipment	Mechanical industry	Manufacture and maintenance of machinery and tractors	Machinery and equipment including maintenance and repairs
		Electrical equipment, and computers & electronics	Electrical and communications equipment	Manufacture of electrical equipment and apparatus Manufacture of apparatus and electronic material equipment	Domestic appliances and electrical equipment Office machines, electronic apparatus and equipment
		Motor vehicles and other transport equipment	Motor vehicles and other transport equipment	Manufacture of automobiles, trucks and buses Manufacture of other vehicles, parts and accessories	Cars, pickups, trucks and buses Parts and accessories for motor vehicles Other transport equipment

Source: IBGE (1994, 1996, 2004, 2018). Compiled by the authors.