DOI: 10.1111/ehr.13228

THE ECONOMIC HISTORY REVIEW

ORIGINAL ARTICLE

From boom to gloom: Brazilian labour productivity in manufacturing relative to the United States, 1912–2019

Cecilia Lara[1] | **Svante Prado**[2]

[1]Universidad de la República

[2]University of Gothenburg

Correspondence
Svante Prado
Email: Svante.Prado@econhist.gu.se

Funding information
Riksbankens Jubileumsfond, Grant/Award Number: P13-0109:1; Jan Wallander and Tom Hedelius Foundation, Grant/Award Numbers: W2009-0161:1, P2013-0003:1

Abstract

Whereas manufacturing seems to hold the key to modern economic growth, the role of manufacturing in economy-wide convergence across countries is debatable. One strand of scholarship argues that productivity levels in manufacturing tend to remain stable across countries, and that economy-wide convergence takes place through structural transformations. Another strand maintains that productivity levels of less-developed countries tend to approach those of developed countries unconditionally, and that deindustrialization thwarts economy-wide convergence. We examine productivity in Brazilian manufacturing relative to the United States, 1912–2019. The result shows dramatic swings in the Brazilian/US productivity ratio, increasing in the decades following the Second World War, peaking in the late 1970s at impressively high levels, and declining precipitously thereafter. This sluggish performance of Brazilian manufacturing since the peak in the late 1970s has probably hindered income convergence with richer countries.

KEYWORDS
Brazil, convergence, industry-of-origin approach, labour productivity, manufacturing

Arguably, the manufacturing industry holds the key to sustainable economic growth.[1] The manufacturing industry is an intrinsic and essential feature of modern economic growth because the dynamic properties of manufacturing often spill over to other sectors. Hirschman showed that these spillover effects stem from the backward and forward linkages that emanate from manufacturing; it demands resources from other sectors as well as supplying other sectors with inputs ranging from tools and equipment to sophisticated machines.[2] Kaldor called the nexus between manufacturing and national income the Third Growth Law, according to which accelerating productivity in manufacturing is also a lever for increased productivity in other sectors.[3] The importance of manufacturing also resonates in the new growth theories insofar as increasing returns to scale, externalities, and learning by doing are essential features of industrialization.[4]

Productivity increases in the manufacturing industry should also play a prominent role in income convergence across countries because industrialization, preferably on a large scale, is one of several conditions a less-developed country has to satisfy to make catching up with a developed country possible.[5] The previous research does not, however, offer conclusive evidence as to whether the manufacturing industry propels income convergence across countries. Rodrik shows that it does so for a large sample of countries, going back to the 1960s at the two-digit industry level using the International Standard Industrial Classification (ISIC).[6] Manufacturing industries tend to behave in the way the unconditional convergence model predicts: if manufacturing lags behind, it will eventually catch up. If Rodrik is right, the size of the manufacturing sector becomes a matter of great importance, as he himself puts it: the larger the share of the manufacturing sector, the greater the potential for economy-wide convergence. Premature deindustrialization delays income convergence in the aggregate. From an economic–historical perspective, however, the short time span of Rodrik's research does not capture long-term shifts in comparative productivity. In addition, the large sample of countries and industries required him to deflate output in all countries by US prices, instead of country-specific prices.

Rodrik's view stands in contrast to an older strand of literature that offers a different understanding of the role of manufacturing. Its main proponent, Broadberry, adopts a very long-term perspective and examines comparable levels of productivity in manufacturing at large.[7] In brief, he employs a historical approach to examine the manufacturing-to-convergence nexus. In his view, economy-wide convergence does not depend on catching up in manufacturing; rather, it should instead be attributed to structural transformations.[8] Owing to the meticulous and

[1] Cornwall, *Modern capitalism*; Amsden, *The rise of "the rest"*.

[2] Hirschman, *The strategy of economic development*.

[3] Kaldor, *Strategic factors*. The Economic Commission for Latin America (ECLAC) adopts a similar perspective: only through massive industrialization, it argued, will less-developed countries break with stagnation and underdevelopment and approach the productivity levels of developed countries: Prebisch, *El desarrollo económico*; Cimoli, *Heterogeneidad estructural*.

[4] Arrow, 'The economic implications'; Romer, 'Increasing returns'.

[5] Bénétrix et al., 'The spread of manufacturing'.

[6] Rodrik, 'Unconditional convergence'.

[7] As one of the referees pointed out, beside the methodological divide, there is also a conceptual difference between these two notions of convergence. Rodrik departs from the assumption that the initial labour productivity level is related to the subsequent growth rate as formalized in a Solow growth model. Broadberry instead compares the level of labour productivity among countries over time, which has a bearing on the notion of economic frontier rather than initial conditions.

[8] Broadberry, 'Manufacturing'; idem, *The productivity race*.

laborious methodology in use, the sample of countries is restricted to a handful of today's developed countries. We therefore do not know if the results are applicable to a sample that includes both developed and less-developed countries. A recent contribution by the authors of this paper, which compares Brazil with Sweden, suggests that the productivity ratio is far from stable.[9]

To assess the contribution of manufacturing to income convergence from the perspective of a less-developed country, we compare Brazil with the United States, and we employ the same historical approach as Broadberry. A greater dependence on manufacturing distinguishes Brazil from most other Latin American countries.[10] In the mid-1970s, the share of manufacturing in gross domestic product (GDP) was 17 per cent for Latin America; for Brazil, however, it was about 30 per cent, rivalled only by Mexico.[11] The Brazilian manufacturing industry also has a long legacy, beginning with textile production and belonging to the late-nineteenth-century wave of development that swept across some countries that were peripheral to the heartland of the first industrial revolution.[12] Frequent attempts were then made to bring capital investments in manufacturing in line with those of the developed countries through technology imports into a wide spectrum of industries.[13] The manufacturing industry also took centre stage in the deliberate state-led efforts to usher in a rapid transformation of the Brazilian economy in the post-Second World War decades, which is known as import substitution industrialization. Besides being relatively large and having a long legacy, the Brazilian manufacturing sector also came to include at least one company – Embraer, in aerospace – operating at the cutting edge of new production technologies.

With this centre of gravity in manufacturing, it would be reasonable to assume that the dynamic properties of Brazilian manufacturing would help to accelerate economy-wide growth rates. Like other Latin American countries, however, Brazil has failed to close the gap with the leading countries in GDP per capita. The catching up in the aggregate that occurred across the twentieth century was meagre.

Our methodological approach is similar to Broadberry's: we adopt a long-term perspective and establish comparative levels of labour productivity.[14] Further, we make a binary comparison between Brazilian and US manufacturing productivity levels, establishing productivity benchmarks at comparable levels and extrapolating these levels across the 1912–2019 period, with endpoints that are determined by data availability.[15] Previous studies have also examined Brazilian productivity in an international context, but we take the comparative approach one step further.[16] We adopt the so-called industry-of-origin approach to benchmarks of comparable productivity levels, but adapt it to allow for the lack of Brazilian data for industrial output in physical terms

[9] Lara and Prado, 'Coming full circle'

[10] Duran, Musacchio and Paolera, 'Industrial growth'; Haber, 'The political economy'.

[11] Bértola and Ocampo, *The economic development*, p. 184.

[12] Stein, *The Brazilian cotton manufacture*; Dean, *The industrialization of São Paulo*.

[13] Suzigan, *Indústria brasileira*.

[14] Even if we call it the 'Broadberry approach', it is important to mention that the list of studies employing this methodology in developed countries is quite long, including, for instance, Fremdling, de Jong, and Timmer, 'British and German'; de Jong and Woltjer, 'Depression dynamics'. This approach is not without critics: Prados de la Escosura, 'International comparisons'; Ward and Devereaux, 'Measuring British decline'.

[15] There is extensive literature on Brazilian productivity growth rates for the economy as a whole covering the most recent decades: Gomes, Pessôa, and Veloso, 'A evolução'; Ferreira, Ellery, and Gomes, 'Produtividade agregada'; Barbosa Filho, Pessôa, and Veloso, 'Evolução da produtividade'.

[16] Maddison and van Ark, 'International comparison'; Hofman and Mulder, 'The comparative productivity performance'; Bonelli, 'Comparações internacionais'.

in earlier censuses.[17] Our new Brazilian/US benchmarks for labour productivity for 1949 complement Madison and van Ark's pioneering benchmark for 1975, Mulder, Montout, and Lopes's benchmark for 1985, and Inklaar and Timmer's for 2005, established as part of the International Comparisons of Output and Productivity (ICOP) project.[18] Our time series of labour productivity, extrapolated from the 1975 benchmark, extend the comparable levels back to 1912 and forward to 2019. The time series extrapolations and the benchmarks for 1949, 1985, and 2005 agree within reasonable margins of error. We have no reason to expect a complete correspondence between benchmarks and time series, given the incompleteness of the Brazilian data.

The Brazilian failure to sustain income convergence relative to the United States appears to be a direct consequence of the performance of manufacturing. Our study reveals one major upswing and one major downswing in the comparative productivity levels of Brazilian manufacturing relative to US levels. The upswing gathered pace leading up to 1950 and accelerated in two brief episodes in the late 1950s and during the 1970s, in the heyday of import substitution industrialization. At its peak in the early 1980s, the Brazilian productivity level in manufacturing was half that of the United States and was only rivalled by developed countries. However, two and a half decades of extraordinary decline, from the mid-1980s until early 2010s, cut the Brazilian/US productivity ratio by half. This downswing resulted in levels close to those in the 1910s, when Brazilian productivity levels in manufacturing ranged from 10 to 15 per cent of the US level. The Brazilian convergence experience had come full circle.

Historical contingencies shaping the trajectory of productivity must be brought into the picture to understand this convergence failure. The last section of the paper, therefore, offers a historical detour composed of important political and institutional factors that shaped the trajectory of productivity in Brazilian manufacturing.

I

In this section, we review the Brazilian trajectory relative to the United States, with a focus on GDP per capita and the structure of output both at the level of the whole economy and at the level of manufacturing. The comparative record in GDP per capita terms shows that Brazil never came close to contracting the income gap with the United States throughout the twentieth century (figure 1).[19] Brazilian GDP per capita ranged between 10 per cent and 15 per cent of the US level until the second half of the 1950s. From then onwards, a steady upward drift in level is discernible, with conspicuous accelerations in the 1970s and the mid-2000s. As a result of the acceleration in the 1970s, the ratio reached about 25 per cent in the late 1970s. Following another upswing in the second half of the 2000s, the level peaked at 30 per cent in 2013. The expansion of the ratio in the 1970s was followed by a rather drastic contraction in the 1980s. The same seems to take place

[17] Rostas, *Comparative productivity*; Paige and Bombach, *A comparison of national output*; Maddison and van Ark, 'International comparison'.

[18] The Brazilian/US estimate was first published in Maddison and van Ark's pilot exercise within ICOP in 1989. Henceforth, we will refer to their 1994 study which offers updated estimates of Brazilian/US productivity levels in 1975: van Ark and Maddison, 'An international comparison of real output'. See also Mulder, Montout, and Lopes, 'Brazil and Mexico's manufacturing performance' and Inklaar and Timmer, 'The relative price of services'.

[19] Our preferred measure would be GDP per worker, in line with the rest of this paper. We have, however, serious doubts about the quality of the Brazilian series of workers for the economy as a whole available in the Penn World Table: see discussion in Bonelli, 'Comparações internacionais', p. 493.

FIGURE 1 Brazilian to US GDP per capita ratios, 1912–2018. *Note*: The Brazilian and US series originates from the 2020 release of the Maddison project. *Sources*: Barro and Ursúa, 'Macroeconomic crises'; Bolt and van Zanden, 'Maddison style estimates'; https://www.rug.nl/ggdc/historicaldevelopment/maddison/releases/maddison-project-database-2020

again after the mid-2010s. Considering the investigated period as a whole, we can see that Brazil has made admirable efforts to catch up but has as yet lacked the sustained leverage to be called 'a developed country' in the twenty-first century. Rather, along with most of Latin America, Brazil seems to have been caught in the famous middle-income trap.[20]

Value added in current prices by sectors from historical national accounts shows that Brazil experienced a structural transformation during the second part of the twentieth century (table 1). We have hesitated to review the pre-1950 period because of the shaky foundations of Brazilian national accounts. In addition, serious discontinuities in the series have also prevented us from showing sectoral shares after 1995.[21] In Brazil, the value-added share of the agricultural sector has declined steadily, in particular since the 1970s, while the industrial sector increased its value-added share from 25 per cent in 1947 to 40 per cent in 1975. The service sector increased its share from about 45 per cent to 55 per cent. These results indicate that changes in the composition of output, an essential component of modern economic growth, also occurred in a less-developed country. The table also presents the share of manufacturing as having peaked at about 30 per cent during the 1970s and the first half of the 1980s, and then declining to about 20 per cent in the mid-1990s.

[20] Gill and Kharas, *An East Asian renaissance.*

[21] Haddad, *Crescimento*; Aldrighi and Colistete, 'Industrial growth'.

TABLE 1 Sectoral composition of GDP for Brazil and the United States, 1950–95, in %

	Brazil				United States			
	Sectoral shares (sum total, 100)				Sectoral shares (sum total, 100)			
	Agriculture	Industry	Services	Manufacturing	Agriculture	Industry	Services	Manufacturing
1950	24	24	52	19	7	35	58	27
1955	23	26	51	20	4	36	59	28
1960	18	32	50	26	4	34	63	25
1965	16	32	52	25	3	34	63	26
1970	12	36	53	27	3	31	67	23
1975	11	40	49	31	3	30	68	21
1980	10	41	49	31	2	30	67	21
1985	11	42	47	32	2	28	71	19
1990	10	37	53	26	2	25	73	17
1995	11	31	57	21	1	24	75	17

Note: Industry includes manufacturing, mining, construction, and utilities.
Sources: Brazil: *Estatísticas do Século XX*; the United States: BEA, GDP by industry: https://apps.bea.gov/iTable/iTable.cfm?reqid=147&step=2&isuri=1.

The composition of US output had become comparatively modern by the mid-1950s, when the value-added share of industry peaked at 35 per cent and the share of manufacturing at 36 per cent. By then, the share of agriculture had already shrunk to 4 per cent. The US share of industry and manufacturing never reached the same level as in Brazil during the 1970s and the first half of the 1980s. During the second half of the twentieth century, the US economy experienced additional structural change as the share of the agricultural sector declined to 1 per cent and the share of services expanded continuously. The share of industry began declining in 1960.

Table 2 presents the pattern of structural transformation by value added in manufacturing. Industries are divided into three groups: natural resources, labour, and engineering.[22] The Brazilian industries that use natural resources intensively have actually increased their share since the early 2000s. This transition has made Brazil even more dependent on natural resources, which now account for more than half of the value added in total manufacturing. The share of engineering-intensive industries increased from 13 per cent in the 1940s to 37.6 per cent in the 1990s, but has declined somewhat since then. The share of labour-intensive industries has declined continuously; in fact, the drop from 43.5 to 14.5 per cent is quite remarkable. The changes over time would have been similar if we had looked instead at the share of employment across the three groups, but the relative magnitudes would have been slightly different.

As in Brazil, the share of natural-resource-intensive industries in the United States has increased since the 1990s. The share of labour-intensive industries has also declined, from 34 to 12.4 per cent between 1940 and 2010, as a result of mechanization and globalization. It is a noteworthy decline, though somewhat more modest than that of Brazil. In the 1950s, owing to early

[22] The first group, natural resources, includes: food, beverages, tobacco, paper, chemicals, petroleum, rubber, and plastics. The second, labour, includes: textiles, apparel, leather, wood, furniture, printing, non-metallic minerals, and miscellaneous. Finally, the third group, engineering, includes: metals, electrical and non-electrical machinery, vehicles, and transport equipment. See: Katz and Stumpo, 'Regímenes sectoriales'; ECLAC, *Progreso técnico*; A. Lavopa, 'The impact of sectoral heterogeneities in growth and catching up: empirical evidence for Latin American manufacturing industries', UNU-MERIT, document presented in Conference Globelics (2011).

TABLE 2 Value added by industry group for Brazil and the United States, 1940–2010, in %

	Brazil			United States		
	Natural resource intensive	Labour intensive	Engineering intensive	Natural resource intensive	Labour intensive	Engineering intensive
1940	44	43	13	31	34	35
1950	40	44	15	29	33	38
1960	40	33	27	28	26	46
1970	38	30	32	29	25	46
1980	36	29	36	30	25	45
1990	40	22	38	34	18	48
2000	50	18	32	34	17	49
2010	52	15	34	44	12	43

Note: Natural resource intensive includes food, beverages, tobacco, paper, chemicals, petroleum, rubber, and plastics; labour intensive includes textiles, apparel, leather, wood, furniture, printing, non-metallic minerals, and miscellaneous; and engineering intensive includes metals, electrical and non-electrical machinery, vehicles, and transport equipment.
Sources: Brazil: *Censo Industrial do Brasil*, 1939, 1949, 1959, 1970, and 1980, and *Pesquisa Industrial Annual* (PIA), 1990, 2000, and 2010; the United States: *US Census of Manufacturing*, 1939, 1947, 1957, 1967, and 1977, and *US Annual Survey of Manufactures*, 1990, 2000, and 2010.

industrialization based on a growing engineering sector, the US share of engineering-intensive industries was higher than the peak of the Brazilian share in the 1990s. These industries accounted for almost half of the value added in the 2000s before declining to 43.4 per cent in the 2010s.

In sum, across the twentieth century, Brazil has undergone the kind of structural transformation that is characteristic of developed countries. The comparative record of GDP per capita reveals, however, that the gap relative to the United States has remained large. Brazil has experienced modern economic growth for a long time, but it has not managed to sustain the acceleration in growth rates needed to catch up with the United States. In a Latin American context, however, Brazil may be considered an industrial country.[23] The question is, then, why this potential – embedded in the industrial basis and in the so-called unconditional benefits of backwardness – did not translate into a perennial force of income convergence. The following sections will examine the causes of the Brazilian convergence failure with a focus on the manufacturing industry from a comparative perspective.

II

In this section, we will review the methodological approach we used to establish the level of Brazilian labour productivity in manufacturing relative to the United States. Few countries offer censuses of manufacturing that are comparable to those of the United States, and the United States has consequently been the focus of several studies of comparative productivity. By using the United States as a reference country, we expand the potential to relate the Brazilian record to

[23] A perennial theme in Brazilian historiography is the great divide between the south-east and the north-east: see Prado Júnior, *História económical*; Leff, *Underdevelopment*; Barros, *Desigualdades regionais*. In this paper we refer to Brazil as a whole but the reader should keep in mind that industrialization has largely concerned the south-east part of Brazil, with a particular concentration on the Greater São Paulo region: see Cano, *Raízes*.

a global context. In addition, the United States is probably the most common yardstick by which to measure the performance of Latin American countries.[24] Both regions were colonized by Europeans and were dependent on large-scale immigration. This shared experience of colonization ties North America and Latin America together. Also, the ultimate aim of the independence that Latin American countries achieved in the nineteenth century was to break free from their colonial shackles. The new leaders in the post-independence era took a keen interest in the economic and political developments that were under way in the United States and attempted to emulate these US achievements as much as possible.[25]

In the construction of our new benchmark, we draw on what is known as the industry-of-origin approach, which aims to compare output by industry. Two problems encountered when using the exchange rate as a currency converter have led to the development of this approach. First, the exchange rate reflects the relative prices of traded goods, which does not suit our focus on all manufactured goods. Second, the exchange rate is also under the sway of short-term capital movements and deliberate attempts by central banks to peg the rate so as to achieve other economic policy objectives. Employing the industry-of-origin approach eliminates the problems associated with the exchange rate. This approach has two different modes: the first dates back to Rostas, who compared physical output per worker directly, and the second to Paige and Bombach, who constructed unit value ratios to convert the nominal output into real output.[26] The basic requirement for both these modes is access to information on output in physical units. Information on physical output sometimes accompanies industrial censuses, as in the case of the US Census of Manufactures and the UK Census of Production over the entire twentieth century.

Since the late 1980s, the industry-of-origin approach has been the basis for a string of studies on comparative productivity conducted within the framework of the ICOP project. Two of these studies have established Brazilian/US productivity benchmarks: van Ark and Maddison for 1975 and Mulder, Montout, and Lopes for 1985, both of which are important building blocks for our attempt to examine the long-term movement of Brazilian/US labour productivity.[27] These two benchmark years coincide with the publication of two of the Brazilian censuses offering information on output in physical units. Van Ark and Maddison's benchmark for 1975 is based on a wealth of information on physical quantities covering the entire manufacturing sector. They matched products listed in the Brazilian census with comparable products in the *US Annual Survey of Manufactures* for 1975–6. The comparison covers 27 industries, accounting for 61.29 per cent of Brazilian gross output and 89.10 per cent of US gross output.[28] The authors estimated a set of country-specific unit values on the basis of physical output indicators and the corresponding prices of 276 Brazilian products and 417 US products. For each industry, they established price and quantity ratios weighted by either Brazilian or US quantities. The geometric mean of the two provides the final conversion rate. To establish productivity ratios, the authors divided the comparable volume measures of value added by the number of people employed. Mulder, Montout, and Lopes produced a benchmark for 1985 using the same method employed by Maddison and van Ark. Their benchmark will be used as a cross-check of our time series extrapolation from the van Ark and Maddison benchmark. We

[24] Fukuyama, *Falling behind*; Engerman and Sokoloff, 'Factor endowments'.

[25] Bértola and Ocampo, *The economic development.*

[26] Rostas, *Comparative productivity*; Paige and Bombach, *A comparison of national output*.

[27] Maddison and van Ark, 'International comparison'; van Ark and Maddison, 'An international comparison of real output'; Mulder, Montout and Lopes, 'Brazil and Mexico's manufacturing performance'.

[28] van Ark and Maddison, 'An international comparison of real output'; p. 48.

will also use the estimated level for 2005 provided by the Groningen Growth and Development Centre's Productivity Level Database as an additional cross-check.[29]

Our aim is to establish an additional productivity benchmark for 1949. The use of the industry-of-origin approach poses a particular challenge for Brazil because pre-1975 versions of the *Censo Industrial do Brasil* do not offer information on output in physical terms. Four industrial censuses were published in the first half of the twentieth century. The first appeared in 1907 and is incomplete and useless for our purpose.[30] The procedure used in the official censuses of 1919, 1939, and 1949 improved the coverage, which made these later publications reliable summaries of key aspects of Brazilian manufacturing. One important reason why we chose 1949 as the benchmark year is that its estimated value can be cross-checked by an independent time series of labour productivity (see appendix).

We use wholesale prices instead of unit values from the industrial census to circumvent the lack of output in physical terms pre-1975. With this empirical strategy, we comply with the industry-of-origin approach and avoid using the exchange rate.[31] There is, however, no abundance of Brazilian wholesale prices either. *Fundação Getulio Vargas* (FGV) constructed a wholesale price index beginning in 1944 but never published the particulars of the products underlying the index. Furthermore, the statistical authority in Brazil, *Instituto Brasileiro Geografia e Estatística* (IBGE), did not publish price statistics despite a deliberate effort to collect wholesale prices.[32] The only price information available is found in Gouveia de Bulhões' article '*Índices de preços*', published in *Revista Brasileira de Economia*, which contains annual price quotations for a wide range of products from 1938 to 1947.[33] He lists 99 products and, if sub-categories are included, the list grows to 133 products. The price quotations are wholesale prices free from retail markup, and refer to Rio de Janeiro, the *Distrito Federal* (federal district) at that time.[34]

The availability of US prices is sufficiently detailed for product matching, thanks to the wholesale prices underlying the various indices issued by the Bureau of Labour Statistics, which have been reported annually since at least the beginning of the twentieth century. Most of the items appear in the list of about 180 products and prices published in the *Statistical Abstract of the United States*, and a few of them appear in the macro history database under the auspices of the National Bureau of Economic Research (NBER).[35] Other products were obtained through the *US Census of Manufactures*, thus providing unit values or factory gate prices. The unit values were converted to wholesale prices by multiplying by a factor of 1.25, the markup found for Portland cement that was available both in the *Census* and the *Statistical Abstract*. Product heterogeneity, along with a

[29] Inklaar and Timmer, 'The relative price of services'.

[30] In fact, it was not a governmental report because the national manufacturers' association was responsible for the survey. The association feared that company owners would ignore a survey conducted by the federal government. Several industries were excluded because of the deficient coverage of São Paulo. The data presented by the census are therefore probably not indicative of manufacturing at large. See Haber, 'The political economy', and Dean, *The industrialization of São Paulo*, for a discussion on the *Censo Industrial do Brasil* in 1907.

[31] Broadberry and Klein, 'When and why'.

[32] See chapter 5, Índices de preços, in Estatísticas históricas do Brasil.

[33] De Bulhões, 'Índices de preços'. Octavio Gouveia de Bulhões was one of the top Brazilian economists at the time, affiliated with FGV and the Minister of Finance (Ministro da Fazenda) between 1964 and 1967.

[34] 'IBGE obtém os preços em grosso por meio de informantes escolhidos' (p. 64). Some of those price quotations appear in *Anuário estatístico do Brasil*, 1941–5, pp. 312–24: https://biblioteca.ibge.gov.br/biblioteca-catalogo?id=720&view=detalhes

[35] http://www.nber.org/databases/macrohistory/contents/chapter04.html https://www.census.gov/library/publications/time-series/statistical_abstracts.html

scarcity of information on product qualities, restricted the number of possible matches to about 50 products in 1947 (see table A3 in the online appendix).[36]

Value added from the industrial censuses of both countries provides the weights used to construct two sets of unit value ratios, and the geometric mean provides the final conversion rate used to convert the different currencies into a single unit of account. The procedure of comparing prices across countries is similar to inter-temporal comparisons of prices and quantities: we compare the price of a commodity in Brazil with the price level of that commodity in the United States, our reference point. In an inter-temporal context, the reference point is a base year. Therefore, the formulas used here have the same properties as inter-temporal index constructions. The second term of formula (1) illustrates the Laspeyres index that compares Brazilian prices multiplied by US quantities with US prices multiplied by US quantities. The second term of (2) illustrates the Paasche index that compares Brazilian prices multiplied by Brazilian quantities with US prices multiplied by Brazilian quantities. To establish the two indices without information on physical quantities, the first terms of the formulas show the actual procedure in operation, weighting the price relatives for each commodity by the share of that commodity in total output. The final measure is the geometric mean of the Laspeyres and the Paasche indices, known as the Fisher index.[37]

$$\text{Laspeyres (US weights)} = \frac{\sum_{i=1}^{n}\left(\frac{P_{Brazil,i}}{P_{US,i}}\right)P_{US,i}Q_{US,i}}{\sum_{i=1}^{n}P_{US,i}Q_{US,i}} = \frac{\sum_{i=1}^{n}P_{Brazil,i}Q_{US,i}}{\sum_{i=1}^{n}P_{US,i}Q_{US,i}} \quad (1)$$

$$\text{Paasche (Brazilian weights)} = 1/\frac{\sum_{n}^{i=1}\left(\frac{P_{US,i}}{P_{Brazil,i}}\right)P_{Brazil,i}Q_{Brazil,i}}{\sum_{n}^{i=1}P_{Brazil,i}Q_{Brazil,i}} = \frac{\sum_{n}^{i=1}P_{Brazil,i}Q_{Brazil,i}}{\sum_{n}^{i=1}P_{US,i}Q_{Brazil,i}} \quad (2)$$

The construction of the final measure of relative prices proceeds stepwise: in the first step, from commodity to groups of similar commodities (industries); in the second, from industries to branches; and in the third, from branches to overall manufacturing. For instance, butter and milk are commodities; dairy product is the group of similar commodities (the dairy industry); and food is the branch that includes the dairy industry, among others. The shares of value added at the group and branch levels mirror the output structure given in each country's industrial census, and do not amount to the sum of output value for the modest sample of commodities compared. This stepwise procedure makes it necessary to re-classify some industries in the industrial censuses of the two countries so that the branches contain similar industries. At each level of aggregation, we assume that the sample of commodities gives a representative picture of relative prices. The

[36] The small sample of matched products stems from insufficient Brazilian data and from disparities in the economic structures of both countries. Binary comparisons between European countries (France, the Netherlands, and Sweden) and the United States also suffer low coverage ratios during the first half of the twentieth century: see Frankema, Woltjer and Smits, 'Changing economic leadership'; Veenstra, *Missed opportunities.*

[37] The Fisher index passes the country reversal test, which means that switching the positions of the denominator and numerator does not alter the results. It also satisfies the factor reversal test, which means that a Fisher price index multiplied by a Fisher quantity index yields a Fisher value index: see Maddison and van Ark, 'International comparison'.

TABLE 3 Wholesale price ratios and shares of value added underlying the benchmark of 1949

	Shares of value added, %		Brazil/US price ratios	
	United States	Brazil	Laspeyres (US weights)	Paasche (Brazilian weights)
Metals				
Iron and steel	0.75	0.43	51.7	51.7
Other metals	0.25	0.57	39.8	39.8
Food				
Sugar	0.04	0.24	16.0	16.0
Coffee	0.03	0.14	11.8	11.8
Miscellaneous	0.02	0.02	23.8	24.4
Grain milling	0.08	0.07	30.0	30.0
Meat and poultry	0.24	0.15	13.3	7.4
Dairy	0.11	0.08	19.8	19.5
Beverages	0.35	0.23	48.5	45.5
Tobacco	0.12	0.07	11.7	11.7
Textile				
Cotton	0.70	0.88	20.6	20.6
Wool	0.30	0.12	22.4	22.4
Chemical				
Chemical products	0.39	0.50	55.4	55.4
Extraction of oil, vegetal essences, and raw animal greases	0.09	0.19	26.5	26.5
Personal hygiene, etc.	0.12	0.27	19.6	19.6
Fossil fuel	0.39	0.04	64.3	64.3

Notes: Textiles includes cotton cloth, bleached cotton cloth, and cotton; wool includes woollen cloth, and wool; glass stone and clay include limestone, Portland cement, and window glass; metals include iron, gross steel sheet, lead bar, copper sheet, tin bar, zinc sheets, silver, and barbed wire; chemicals includes sulphuric acid, bicarbonate of soda, carbonate of soda, calcium carbide and American sulphur, cotton seed oil, soap, gasoline, oil, kerosene, and coal; food includes sugar, coffee, salt, linseed oil, wheat flour, rice, potatoes, lard, fresh meat, egg, butter, cheese, milk, beer, wine, tobacco leaves, and cigars; leather includes soles, shoes, calfskin, and leather of swine; paper includes paper tissue.
Sources: see table A3 in the appendix.

coverage ratio is low because of the small sample of commodities. We acknowledge, therefore, that the margin of error is relatively high.

Table 3 presents the wholesale price ratios along with the value-added weights at the industry level. The products whose prices are likely to be relatively low in Brazil, such as sugar, coffee, and tobacco, have smaller ratios, whereas the Brazilian products whose prices are likely to be relatively high, such as chemicals, metals, and fossil fuels, have higher ratios. At the industry level, the difference between Laspeyres (US output shares) and Paasche (Brazilian output shares) is unavailable because it was not possible to associate a particular product with an output share. The importance of weighting appears instead in table 4, presenting the ratios at the branch level. In most of these branches, the established levels of relative Brazilian wholesale prices turn out to be higher with US output shares (Laspeyres) than with those of Brazil (Paasche). The exceptions

TABLE 4 Wholesale price ratios and value-added shares underlying the benchmark of 1949

	Shares		Brazil/US price ratios			
	United States 1947	Brazil 1949	Laspeyres, (US weights)	Paasche (Brazilian weights)	Fisher	
Metals	0.43	0.17	48.7	44.2		
Glass, stone, and clay	0.03	0.08	45.3	44.1		
Paper	0.10	0.07	42.6	42.6		
Food	0.14	0.29	27.9	15.2		
Textile	0.14	0.26	21.2	20.8		
Leather	0.04	0.04	15.8	15.8		
Chemical	0.11	0.10	51.9	32.8		
Total	1.00	1.00	40.0	22.8	30.2	
Exchange rate						18.7

Sources: For value added for Brazil, see *Censo Industrial do Brasil,* 1949; and for the United States, see *Census of Manufactures*, 1947. For sources of prices see table A3 in the appendix.

are the paper industry, which includes only one product, and the leather industry, whose products did not have output shares.

Table 4 also presents the established unit value ratio for manufacturing at large, the Fisher index, and the exchange rate, showing that they diverge by large degrees in 1947. The price ratio yields 30.1, exceeding the exchange rate of 18.7 by 61 per cent. This discrepancy between the exchange rate and the overall unit value ratio, known as the Penn effect, reinforces the established view that exchange rates should not be used to convert different currencies into a single unit of account, especially in comparisons between developed and less-developed countries.[38] In our case, the exchange rate would have generated a considerable overestimation of the Brazilian level of labour productivity relative to the United States.

Additionally, the large discrepancy between our unit value ratio and the exchange rate informs us about a particular feature of Brazilian economic development. The overvalued exchange rate was a result of the rapid inflation that Brazil experienced in the immediate post-Second World War era. The exchange rate, however, remained fixed. A dramatic overvaluation of the cruzeiro ensued, along with a large increase in imports and a curtailment in exports of manufactured goods. This development was intentional after the mid-1940s.[39] Manipulation of the exchange rate was part of the policy apparatus later known as import substitution industrialization: the exchange rate was overvalued so that industries could import intermediate consumption goods at low prices (including foreign technology), while imports of certain goods (that could be produced in Brazil) were hindered by import quotas.[40] The policy then changed in the 1950s following the implementation of a complex regime of multiple exchange rates, supervised by the government agency *Superintendência de Moeda e Crédito* (SUMOC). An additional trade policy tool designed to reduce the outflow in the late 1940s was to delay authorization for companies to import goods.[41]

[38] Samuelson, 'Facets'.

[39] Abreu, Bevilaqua and Pinho, 'Import substitution'.

[40] Fishlow, 'Origins and consequences'; Duran, Musacchio and Paolera, 'Industrial growth', p. 333.

[41] Baer, *The Brazilian economy.*

Once the unit value ratios for manufacturing at large are estimated, the construction of benchmarks for comparative labour productivity is a straightforward process. Each country's industrial census provides value added by industry. To make the Brazilian industrial census comparable with that of the United States, we have removed all the extractive industries. Differences attributable to the output structure remain unchanged. The new relative price level is used to translate dollar into cruzeiro. Table 5 presents our new estimate of the Brazilian/US productivity ratio in 1949 as reaching 20.3. Accordingly, the Brazilian productivity level remained roughly one-fifth of the US level in the late 1940s. Table 5 also includes the van Ark and Maddison benchmark for 1975, which indicates that the Brazilian level was then 46.5 per cent of that of the United States, as well as the Mulder, Montout, and Lopes benchmark for 1985, indicating a ratio of 42.5 per cent. In sum, the evidence of productivity benchmarks indicates that Brazil experienced an impressive productivity catch-up in manufacturing in the post-Second World War era. In addition, table 5 also includes the Inklaar and Timmer benchmark for 2005 of only 12 per cent. It indicates that Brazil suffered a serious divergence across the 1980s and 1990s. Moreover, the country-specific time series of labour productivity, used to extrapolate the comparative record across the twentieth century, confirms that Brazilian manufacturing converged. The details of these long-term series for both countries are specified in the online appendix, whereas the following section examines the long-term comparative record on the basis of these extrapolations.

III

The series of Brazilian/US levels of comparable productivity were established by time series projection from the benchmark for 1975. The method used here follows the standard procedure for this type of work as used by Maddison and van Ark, and shown in (3) below,

$$\text{Brazil/US LP} - \text{ratio}_{t+1} = \frac{LP_{t+1}^{Br(Cr\$)}}{LP_{t+1}^{US(Cr\$)}} = \frac{LP_{1975}^{Br(Cr\$)} * \left[LP_{t+1}^{Br(Cr\$)}/LP_{t}^{Br(Cr\$)}\right]}{LP_{1975}^{US(Cr\$)} * \left[LP_{t+1}^{US(\$)}/LP_{t}^{US(\$)}\right]}, \tag{3}$$

which illustrates that the growth rates of time series of value added per worker in real prices (cruzeiro in Brazil and dollar in the United States) extrapolate from the established labour productivity ratio in 1975.[42]

Figure 2 makes it possible to examine the long-term productivity records of the two countries separately.[43] The US series is set to 100 in 1975, whereas the Brazilian series is set to 46.5 (the gap that conforms to van Ark and Maddison's benchmark). The figure has a logarithmic scale on the *y*-axis. Table 6 sets out the estimated growth rates for different time spans. Three features of the long-term record are worthy of note. First, convergence in labour productivity took place before 1950.[44] The estimated annual growth rate of Brazilian labour productivity in 1912–49 is 1.96

[42] Maddison and van Ark, 'International comparison'.

[43] The series of output, labour inputs, and productivity are set out in the online appendix, table A2.

[44] In the online appendix we discuss our procedure to establish a time series of labour productivity for Brazil between 1912 and 1949. The estimated growth rate of the time series is cross-checked by the Brazilian census of manufactures for 1919, 1939, and 1949. For those who prefer to play it safe, table 7 also presents the estimated growth rate for the 1919–49 period based on the Brazilian census. The estimated growth rate is 2.01, hence not much affected by the extension of the series back to 1912.

TABLE 5 Brazil/US labour productivity benchmark, 1949

United States, 1947 census					Brazil, 1949 census			Brazil/United States
	Value added		Number of workers	Value added per worker Cr	Value added Cr	Number of workers	Value added per worker Cr	Labour productivity benchmark
	$	Cr						
1949/1947								
Metals	29 061 414	1 348 926 156 156	4 884 927	276.1	7 312 336	140 160	52.2	18.9
Glass, stone, and clay	2 306 480	103 150 737	405 755	254.2	3 427 564	111 635	30.7	12.1
Paper	7 144 374	304 080 873	827 036	367.7	2 971 532	56 796	52.3	14.2
Food	9 666 268	199 232 163	1 202 767	165.6	12 564 173	258 140	48.7	29.4
Textile	9 788 249	205 483 191	2 120 091	96.9	11 392 984	377 985	30.1	31.1
Leather	2 835 666	44 855 577	563 062	79.7	1 528 971	26 464	57.8	72.5
Chemical	7 380 508	304 541 898	636 068	478.8	4 450 644	60 992	73.0	15.2
Manufacturing as a whole	74 142 218	2 238 827 191	11 916 183	187.9	47 614 903	1 095 059	43.5	23.1
Adjusting for different benchmark years								
1949				215.7				20.2
1975								46.5
1985								42.5
2005								12.0

Note: Manufacturing as a whole also includes the wood industry and miscellaneous industry. The conversion from US dollar to Brazilian cruzeiro (cr) is based on the price ratios in table 4. The US level of labour productivity taken from the *Census of Manufactures of 1947* has been adjusted to 1949 by the movement of the output to labour ratio as indicated by our time series used for extrapolation (table A2 in the appendix). The ratio increased by 14.78 per cent from 1947 to 1949, which gives us the benchmark of 20.3 for 1949.

Sources: Benchmark for 1975: van Ark and Maddison, 'An international comparison', p. 84, table 7.1; benchmark for 1985: Mulder, Montout and Lopes, 'Brazil and Mexico's manufacturing performance', p. 17, table 6; benchmark of 2005: GGDC productivity level database; benchmark for 1949: see sources for table A3 in the appendix.

FIGURE 2 Brazilian and US series of labour productivity 1912–2019 (US in 1975 is 100). *Note*: Logarithmic scale on the *y*-axis. Our time series of labour productivity are used to extrapolate the development of labour productivity from the benchmark in 1975. In 1975, the US series is set to 100 and the Brazilian is set to 46.5 according to the Brazil/US benchmark of labour productivity in 1975 (see table 5). The series is set out in the appendix (table A2). The dashed line for Brazil indicates that the series of employment is estimated by a presumed relationship between output and labour productivity (see appendix). *Sources*: The time series are set out in table A2 in the appendix and the sources are listed in the appendix.

TABLE 6 Growth rates for labour productivity across different time spans, 1912–2019

	Mean annual growth rate rates, %			
	Brazil	**United States**	**Diff (Brazil–United States)**	**Characteristic**
1919–49	(2.01)	(1.17)	(0.84)	Convergence
1912–49	1.96	1.05	0.90	Convergence
1950–80	2.28	1.24	1.04	Convergence
1980–2019	−0.13	1.89	−2.01	Divergence

Sources: See figure 2.

per cent, whereas the US productivity series for the same period was only 1.05 per cent; in other words, the US manufacturing sector developed at a significantly slower pace. Second, additional dissimilarity in productivity growth rates took place between 1950 and 1980, when the annual rate of productivity growth in Brazil was 2.28 per cent, exceeding by a wide margin the US rate of 1.24 per cent. Third, another great dissimilarity appeared after the early 1980s, when US productivity continued to grow and indeed accelerate (1.89 per cent in 1980–2019), whereas the Brazilian rate

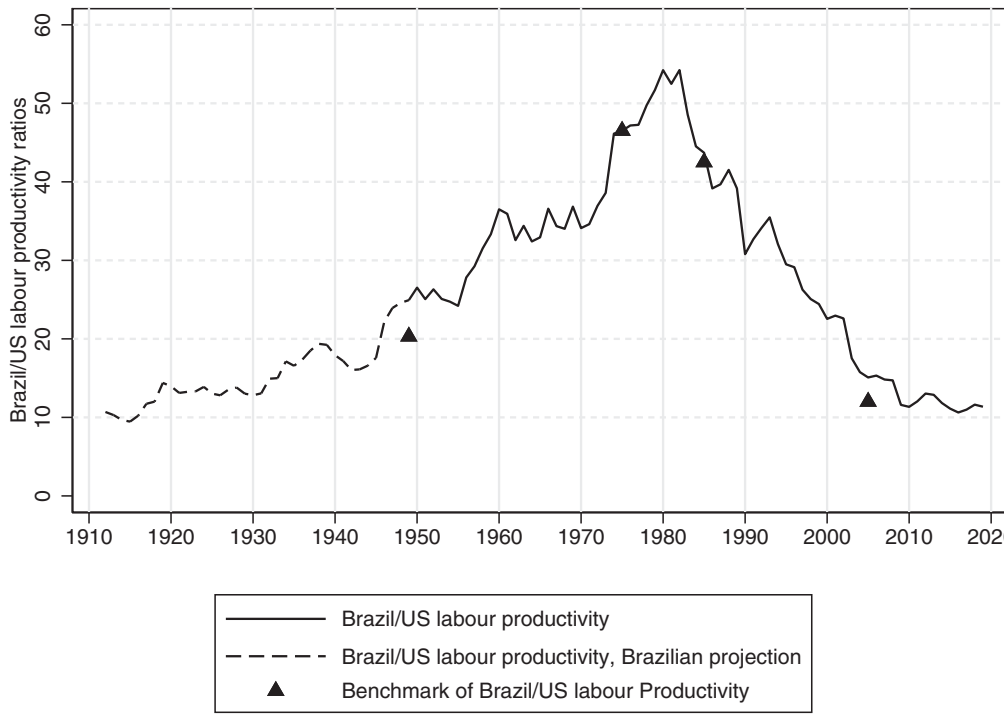

FIGURE 3 Brazilian to US labour productivity ratios, 1912–2019. *Notes*: The ratios are derived by dividing the Brazilian series by the US series, both of which are shown in figure 2. The triangles denote the benchmarks for 1949, 1975, 1985, and 2005 (see table 5). *Sources*: see figure 2.

lost momentum altogether. Between 1980 and 2019, the Brazilian productivity series remained essentially flat (−0.13 per cent), with seriously detrimental effects on Brazil's potential to catch up to the richer countries.

From a Brazilian viewpoint, the series of productivity ratios in figure 3 forms a conspicuous boom-and-bust pattern. The line in figure 3 displays the ratios between 1912 and 2019, whereas the triangles mark the benchmark levels of 1949, 1975, 1985, and 2005. Between the early 1910s and the late 1940s, the Brazilian level of labour productivity increased slowly from about 10 per cent to about 20–25 per cent of the US level. Two episodical growth spurts, the first in the late 1950s (partly offset by a decline) and the second in the 1970s, brought the Brazilian level to half of the US level by the late 1970s. The decline from this peak was precipitous and continuous. By the 1990s, the ongoing contraction of the ratio had erased what the growth spurt in the 1970s had achieved, and by 2010 the ratio had reverted to its starting point 100 years earlier.

Our evidence is a combination of benchmarks and time series projection that allows us to control for possible inconsistencies between the estimated benchmark levels and the estimated levels based on time series projections. The triangles of 1949, 1985, and 2005 should preferably move in tandem with the time series. Both the time series projection and the benchmarks testify to the Brazilian convergence from the 1940s to the mid-1970s, even though the two measures diverge somewhat in relation to the point at which the acceleration commences. The time series deviates from the benchmark for 1949 by 4.7 percentage points. Moreover, both the projection and the benchmarks for 1985 and for 2005 indicate that the ratio declined throughout the 1980s and 1990s. The time series deviates from the benchmark for 1985 by Mulder, Montout, and Lopes by

1.2 percentage points and from the benchmark for 2005 by Inklaar and Timmer by 3 percentage points.

We have no reason to expect complete correspondence between benchmarks and time series extrapolations. First, the challenge posed by the incompleteness of the Brazilian sources increases the margin of error. In our case, we had to resort to a limited sample of wholesale prices instead of the preferred solution, which would be unit value ratios from each country's manufacturing census. Second, some authors argue that we should not expect perfect symmetry between benchmarks and extrapolations even if we had evidence originating from unimpeachable sources. The reason for this expectation, they explain, is that index number problems give rise to increasing asymmetry between benchmarks and projections as the projected time span increases.[45] This discussion of benchmark and time series extrapolation, however, refers to GDP figures. Drawing on the experiences of time series extrapolations in the realm of binary comparisons of comparable levels of real output in manufacturing, we do not find support for the idea that the inconsistency between benchmarks and extrapolations increases systematically with the length of the time series. Instead, the error margins do not form a predictable pattern across time.[46]

The reasonable correspondence between the four benchmarks and time series lends support to the rather high levels of Brazilian productivity in 1975 and 1987 estimated by van Ark and Maddison and Mulder, Montout, and Lopes. Meanwhile, Bonelli claimed that the Brazilian productivity level in manufacturing, even in the peak years of the late 1970s, never exceeded 18 per cent of the US level. He has employed an expenditure approach (PPP) and not the industry-of-origin approach which is the most widely accepted method for international productivity comparisons.[47] According to his claim, the Brazilian level in 1912 would be 3.7 per cent, and in 2013 it would be 4.3 per cent. Since the Brazilian/US GDP per capita ratio is 30 in 2013, it is hard to accept this very low level by projection.[48]

The high frequency with which the United States is used as a reference country allows us to put our numbers into a wider historical context. Table 7 presents the Brazilian levels along with a sample of other countries for the benchmark years 1935 (approximately), 1973, 1987, and 2005, using the level of US productivity as a yardstick (US = 1000). Countries are ranked by their ratios in ascending order in 1987. The rankings in 1973 and 1987 indicate that only developed countries had levels higher than those of Brazil, giving the impression that Brazil was well on the way to becoming a developed country in the 1970s and early 1980s, at least according to this criterion. Countries like South Korea and Taiwan, which would later climb the ladder quickly, were actually lagging significantly behind. The evidence for the mid-1930s is scarce, but it places Brazil somewhere between China and fast-growing Germany and Sweden (both of which had reached half the level of the United States). Brazil was behind both Korea and Chile by the mid-1930s. Table 7 also presents productivity convergence in manufacturing as being above all an experience shared among developed countries. Except for Canada, all countries that had a higher level of productivity than Brazil in 1987 had narrowed or surpassed the US level by 2005. With the exceptions of South Korea, clearly an overachiever, and Portugal, a member of the European Union since 1986, no country in the upper half of the table has accomplished any noteworthy narrowing of the

[45] Prados de la Escosura, 'International comparisons'; Ward and Devereaux, 'Measuring British decline'.

[46] See for instance Broadberry, *The productivity race,* p. 36, table 3.1.

[47] Bonelli, 'Comparações internacionais'. He builds on value added taken from National Accounts provided by GGDC and converted into dollars using the exchange rate.

[48] In this projection, we have substituted the van Ark and Maddison benchmark of 46.5 for 1975 with a benchmark of 16, based on the graph in Bonelli, 'Comparações internacionais', p. 508, figure 10.

TABLE 7 Available estimates of labour productivity in manufacturing, *c.* 1935, 1973, 1987, and 2005

	The productivity level of the United States, 100			
	***c.* 1935**	**1973**	**1987**	**2005**
Tanzania		12	4	
Zambia		11	5	
China	7		6	10
Indonesia		10	8	10
India		8	9	5
Egypt		14	19	
Hungary		18	20	25
Poland		26	21	23
East Germany		24	23	
Morocco			23	
Czechoslovakia		25	24	23
Portugal		28	25	36
Taiwan		19	25	
USSR			25	16
Korea	23	17	27	48
Chile	25			47
Mexico		34	28	20
Brazil	**17**	**39**	**40**	**15**
Spain		43	45	73
Australia		46	48	72
United Kingdom	47	53	54	107
Finland		55	66	127
Sweden	52	75	68	95
West Germany	52	78	70	
France		72	71	108
Japan	24	67	76	82
Canada		84	78	65
Belgium		61	79	126
The Netherlands		73	83	139

Note: The productivity level of Brazil is derived from our time series extrapolation (see figure 2 and table 5).
Sources: 1973 and 1987: ICOP summary table: https://www.rug.nl/ggdc/docs/icopsumtab2.pdf.
For *c.* 1935: China, Korea, and Japan: Yuan, Fukao and Wu, 'Comparative output', p. 340, table 8; Sweden: S. Prado and Y. Sato, 'Sweden chasing the American and British productivity frontiers in manufacturing, 1869–2010', Paper presented at the Sound Economic History Workshop, Trondheim (June 2019); the UK: Veenstra, *Missed opportunities*; Chile: Lara, *Manufacturing performance*; 2005: Inklaar and Timmer, 'The relative price of services'.

productivity gap. The Brazilian experience, however, stands out because of the precipitous drop from 1987 to 2005. Mexico displays a similar trajectory though falling less steeply.

The result of our Brazilian investigation and the overview of other countries' development paths in table 7 bring into question Rodrik's view of unconditional convergence in manufacturing.[49] For

[49] Rodrik, 'Unconditional convergence'.

Brazil, the annual growth rate of productivity in manufacturing has been essentially zero since the early 1980s. This stagnation has entailed great divergence in productivity levels relative to the developed countries, and it underscores the significance of less-developed countries achieving sustained growth rates without serious setbacks. The long spell of zero growth in productivity does not square with Rodrik's concern that deindustrialization is the foremost obstacle for convergence. He argues that late-developing countries will fail to achieve economy-wide convergence because manufacturing industry, which is supposed to promote convergence, decreases as a share of GDP.[50] The Brazilian case, alongside other less-developed countries in table 7, suggests that it is not only the size of manufacturing that thwarts the prospects of convergence in the aggregate, but also the fact that productivity levels in manufacturing fail to catch up with those of the United States.

The radical shifts in comparative productivity levels associated with the Brazilian record also contrast with Broadberry's view of long-term stability.[51] In Brazil, the manufacturing industry must have played a key role in propelling convergence in GDP per capita levels, at least until the early 1980s. The Brazilian productivity level relative to the United States increased from about 10 to 50 per cent from the early 1910s to the late 1970s. This achievement notwithstanding, the GDP per capita ratio only improved from about 10 to 26 per cent. Considering this incongruence, the performance of the Brazilian manufacturing industry appears outstanding. Sluggish performance in sectors other than manufacturing must have dragged down the Brazilian GDP per capita level relative to the United States, which stresses the role of services and agriculture in income convergence. Since the 1980s, on the other hand, comparative productivity in manufacturing has fallen behind – the ratio declined from about 54 to 13 between 1980 and 2019. This gloomy record runs counter to those forces, most notably the commodity price boom of the 2000s, that propelled economy-wide growth rates after 2004, and entailed a brief spell of convergence in GDP per capita terms in relation to the United States.

Since the Brazilian experience refuses to obey the implied logic of the theoretical frameworks of convergence, it is also necessary to consider the historical circumstances that have shaped the environment for productivity in manufacturing. The following section of this paper, therefore, offers a review of the key developments in economic policy and the institutional foundations for output and productivity in Brazilian manufacturing since the early twentieth century.

IV

Brazil embarked on a path of industrialization in the late nineteenth century centred on textile production. The achievements of this early phase of industrialization were long overlooked in the historiography, influenced by Furtado's epochal study which identified the 1930s as the beginning of an industrialization wave that was intended to counter the adverse effects of the volatile world market on coffee prices.[52] The second wave of contributions that emerged in the 1960s and 1970s

[50] According to a recent report prepared by the *Departamento de Pesquisas e Estudos Econômicos* (DEPECON), FIESP-CIESP (2015), and based on IBGE's data, Brazil's share of manufacturing proper in GDP peaked in 1985 at 21.6 per cent, declined to 16.4 per cent in 1995, and then to 10.9 in 2014. These figures are different from our table 1 that included mining and transport as well.

[51] Broadberry, 'Manufacturing'.

[52] Furtado, *Formação econômica*.

shifted focus to pre-1930 industrialization.[53] The characteristics of this early development phase, it is argued, hold the key to explaining the growth of manufacturing after the Great Depression in the early 1930s.[54] A prominent example of such a reorientation was Dean.[55] Although coffee exports were still the prime focus, he emphasized the spillover effects from exports to other sectors in the state of São Paulo. Income arising from coffee exports spurred investments in new technologies in manufacturing and agriculture. The role of the state in the pre-1930 era has also received attention. Topik argues that the Brazilian state at that time was already one of the most interventionist in Latin America, with its tentacles reaching into finance, the coffee trade, railroads, and industry.[56]

Notwithstanding early developments in textiles and other consumer goods industries, most authors concur that industrialization was slow in coming and depended almost entirely on foreign technologies. Until the 1930s, when the domestic production of some capital goods began to substitute for imports, Brazil was dependent on imports of a wide range of machines and sophisticated equipment.[57] The corollary of little experience in the production of capital goods was the decisive role played by foreign entrepreneurs in the development of sophisticated manufacturing processes and in the establishment of heavy industries such as steel and cement production. Whichever sign of sophistication one encountered, it almost certainly came from abroad. In addition, the use of electricity lagged significantly behind. In 1907, only 4.2 per cent of the power used by industry was based on electricity. In the United States, the corresponding figure was 20 per cent in 1909.[58] Fishlow argued that 'as a whole, industrial production was limited and unsophisticated'.[59] The textile industry dwarfed most other industries, with a quarter of total output in 1920. It was rivalled only by all food processing industries combined, which accounted for 33 per cent of output.[60]

The productivity level of Brazilian manufacturing was low relative to developed countries in the early 1910s. This lagging behind is an expected outcome provided the premature characteristics of the industrial sector until 1930. With this prematurity in mind, our established levels, ranging from 10 to 15 per cent of the US level, seem reasonable. As evidenced in table 7, similarly low levels relative to the United States were common in other less-developed countries during the interwar years. Part of this wide gap is of course also attributable to the very dynamic features of the US manufacturing sector in the first half of the twentieth century.[61] However, the wide productivity gap could also have heralded a growth spurt that would eventually lead to convergence. Little if any of that convergence potential was realized before the 1930s, however; the development of the Brazilian to US productivity ratio failed to gather momentum before 1930. Topik has argued that one important reason for the mediocre pre-1930 record to which our result testifies is that the state did not engage sufficiently to foster development.

[53] Dean, *The industrialization of São Paulo*; Simonsen, *Evolução industrial*; Villela and Suzigan, *Política do governo*; Peláez, *História da industrialização;* Suzigan, *Indústria brasileira;* Stein, *The Brazilian cotton manufacture.*

[54] Haber, 'The political economy'.

[55] Dean, *The industrialization of São Paulo.*

[56] Topik, *The political economy.*

[57] Suzigan, *Indústria brasileira.*

[58] Du Boff, *Electric power*, pp. 60.

[59] Fishlow, 'Origins and consequences', p. 322

[60] Ibid., p. 323.

[61] David and Wright, 'General purpose technologies'; Field, 'The most technologically'.

The role of the state takes central stage in the developments of Brazil during the 1930s onwards, and it proved conducive to closing the gap in productivity levels. The government of Getúlio Vargas (1930–45), particularly during his mandate known as *Estado Novo* (Second Republic, 1937–45), implemented important institutional changes with increasing centralization and state intervention in the economy. This shift in power also occurred against the backdrop of two great external crises that hit Latin America between 1930 and 1945, the Great Depression and the Second World War, both of which curtailed international trade. These crises prompted the Brazilian state to take on greater responsibility for industrialization and economic development in general.[62] The contour of this development regime is familiar; whether it is labelled as import substitution industrialization, state-led development or developmentalism, it fits with the overall Latin American pattern.[63] The state began to play a key role in planning for industrialization and structural transformations, as exemplified by the establishment of the corporate giants: *Companhia Siderúrgica Nacional* (CSN), a steel company; *Conselho Nacional do Petróleo* (CNP, renamed *Petrobrás* in 1951), an oil company; and *Companhia Hidroeléctrica de São Francisco* (CESF), a hydroelectric company. Some of these state-led investments had been advised by the Cooke Mission, a group of US technicians supported by the Brazilian and US governments visiting Brazil in 1942 and 1943. Our series of productivity ratios suggest that the environment was favourable for catching up; the Brazilian to US ratio increased from 10 to 15 per cent in the early 1910s to about 25 per cent in the late 1940s.

The scale of the state-led approach to development leapfrogged in the 1950s. Several institutions designed to foster widespread industrialization were established, such as the *Banco Nacional do Desenvolvimiento Econômico* (BNDE, National Economic Development Bank) in 1952 with the aim of financing infrastructure projects and to offer support to specific industries.[64] The latter half of the 1950s saw a remarkable acceleration in efforts to leverage development through industrialization. This period coincides with the coming to power of Juselino Kubitschek, who began by establishing a Development Council that designed the *Programa de Metas* (Programme of Targets). This development plan covered energy, transportation, food supply, basic industries, and education.[65] Brazilian labour productivity grew steeply in the 1950s, and narrowed the gap with the United States; the Brazilian to US manufacturing ratio increased from about 25 to 35 per cent, which was an achievement only rivalled in the 1970s.

Regional inequality accompanied the massive state-led effort to modernize Brazil. Our figures on manufacturing output and employment refer to Brazil but pertain largely to the south-east region. The post-Second World War decades exacerbated the preponderance of economic development in the south-east, previously driven by gold discoveries in the eighteenth century and massive investments in coffee plantations in the nineteenth century. This shift was now accelerated by the establishment of the automotive industry in the 1950s, located in the south-east of Greater São Paulo in an area known as ABC Paulista after the initials of the neighbouring cities of Santo André, São Bernardo do Campo, and São Caetano do Sul. In this region, foreign companies like Ford, Volkswagen, and Willys–Overland built plants to produce cars for the South American markets. The automotive parts industry also grew rapidly in the same region.[66] The post-Second World War period, moreover, witnessed a dramatic shift in population from rural to urban areas,

[62] Villela and Suzigan, *Política do governo.*

[63] Bulmer-Thomas, *The economic history of Latin America*; Bértola and Ocampo, *The economic development.*

[64] Baer and Kerstenetzky, 'Import substitution'; Suzigan, 'Experiência histórica'.

[65] Orenstein and Sochaczewski, 'Democracia'

[66] Colistete, *Labour relations.*

reaching an urban share exceeding 50 per cent of the population by the 1970s.[67] Urbanization and industrialization developed in parallel, which spurred domestic demand for consumer goods and services.

The flipside of the growing concentration of industries and wealth in the south-east of Brazil was emigration from the drought-stricken north-east, dominated by rather primitive agriculture. This emerging bifurcation cut through all sorts of economic, social, political, and cultural aspects. The resulting regional heterogeneity, a staple in the historiography of Brazilian economic history, is sometimes claimed to have deep historical roots associated with resource endowments and colonial institutions.[68] In economic terms, the north-east depended from the outset on sugar plantations and large-scale use of African enslaved people. Slavery then spread to other regions in Brazil.[69] The north-east region has struggled, with little success, to move away from the archaic production structure of the past towards the modernization of industry and service sectors. The development of the south-east stands in sharp relief against that of the north-east. Coffee production, which was the dominating cash crop grown in the south-east, proved conducive to spillover effects in other sectors.[70] The immigration of European workers exceeded the influx of enslaved people by the 1880s. Early on, the south-east, and in particular the Greater São Paulo region, became the workhorse of the Brazilian economy, thanks in no small degree to massive industrialization.[71] As a result of this dynamic, the regional gap expanded during the twentieth century, so Brazil still suffers heavily from regional inequality and a dual structure of the economy.

Compared with the feverish development of the 1950s, the first half of the 1960s was marked by a backlash in both political and economic matters. The growth of the economy slowed down considerably in the midst of soaring inflation and increased political tensions. The growth of labour productivity in manufacturing decelerated, so convergence halted for about a decade. João Goulart, who accidentally became president in 1961 following the resignation of Jânio Quadros, was overthrown in a military coup in 1964.

The miracle years of the late 1960s and early 1970s brought surging growth rates. By 1964, under a military government, Brazil began to employ a development strategy that brought more openness and support for the private sector. Several reforms were undertaken to strengthen the economy, such as lowering inflation, modernizing capital markets to ease financial capital constraints, increasing investments in public infrastructure and heavy industry, and opening up the economy to foreign capital investments. It took some years for these new policy stances to bring about accelerating growth rates. Progress in productivity increased cautiously until 1968. Growth then began to gather speed in 1968 and the period between then and 1973 has been called the *Milagre Econômico* ('miracle years'), under the administration of General Emilio Medici. Some of that leverage originated from an aggressive programme known as *Planos Nacionais de Desenvolvimento* (National Development Plans) that was launched in 1971. It aimed to improve telecommunications

[67] Wagner and Ward, 'Urbanization'.

[68] Prado Júnior, *História Económica*; Leff, *Underdevelopment*; Barros, *Desigualdades regionais*; Engerman and Sokoloff, 'Factor endowments'. While the regional gap remains significant relative to most other countries, it has also been grossly overstated by use of faulty wage data in economic-history research: see Pereira, 'The north-south divide'; Molinder, Pereira and Prado, 'Poles apart'.

[69] The south-east depended also on enslaved labour. Circa 1820, the share of slaves in the population was even higher in some south-east states than in the north-east: see Pereira, 'Poor man's crop?'; Palma et al., 'Slavery and development'.

[70] Dean, *The industrialization of São Paulo.*

[71] Cano, *Raízes.*

and transport as a means to facilitate labour mobility and market integration.[72] Manufacturing was the leading sector, with two-digit annual growth rates for many industries.

Under General Ernesto Geisel's administration, state intervention in the economy peaked. A second and even more comprehensive programme was launched in 1975 by the administration of Geisel. This time, the plan was designed to boost import substitution industrialization for basic industrial products and capital-intensive sectors. Fiscal credits and tax incentives were used to stimulate the private sector and state-owned enterprises to pursue import substitution projects. The plan was also composed of additional efforts to improve energy supply and infrastructure for communication and transport.[73] Keeping in mind that the US economy, like that of other developed countries, suffered decelerating growth rates and structural crises in the wake of soaring oil prices and stiff competition from East Asia, the 1970s stand out as the golden years for Brazilian convergence. Between 1970 and 1980 the productivity ratio increased from about 35 to 55. Relative to the United States, Brazilian manufacturing accomplished as much in this decade as in the previous six decades combined.

Research is divided on the lessons learned from the massive effort to foster modernization and industrialization in Brazil during the post-Second World War decades. Viewed from the vantage point of the late 1970s, it would have been reasonable to argue that the achievements of the previous decades were largely the outcome of policies that favoured catching up, implemented by the Brazilian state, whether under democratic or military rule. Indeed, the acceleration of labour productivity growth rates in manufacturing was impressive. Annual productivity growth in manufacturing as a whole was 2.25 per cent in 1945–80. However, these figures mask some variations over time and across industries. The most impressive growth rates were accomplished in the 1950s (2.22 per cent) and between 1970 and 1980 (2.78 per cent). Progress was considerably slower in the 1960s (1.67 per cent). A shift–share analysis that decomposes the aggregate into its constituent components testifies to the importance of within-industry advances, but it downplays the importance of the changing industry-specific shares of employment.[74] In line with the literature on shift–share analysis, we may attribute these productivity advances within industries to actual efficiency gains from technological changes.[75] Nonetheless, some authors voiced their dissatisfaction with import substitution industrialization as early as the late 1960s and early 1970s, arguing that protectionism and selected subsidies had brought inefficient firms and high-cost industries into existence.[76] Later, the state-led development strategy came under fierce attack from different theoretical perspectives. Import substitution industrialization was criticized from the perspective of neoclassical theory, which argues that economies should specialize on the basis of comparative advantages, whereas critique from neo-structuralism focused on the rent-seeking behaviour of national entrepreneurs.[77]

The latter half of the 1970s includes the run-up to the debt crises. Even though the economy kept growing at a respectable pace after the 'miracle years' the cracks soon began to appear. The push for further import substitution industrialization in the latter half the 1970s was a consequence of increased public spending, unbalanced government accounts, rising foreign debt, and runaway

[72] Hermann, 'Reformas'.

[73] Hermann, 'Auge e declínio'.

[74] Aldrighi and Colistete, 'Industrial growth'.

[75] Timmer and Szirmai, 'Productivity growth'.

[76] Hirschman, 'The political economy'; Baer, 'Import substitution'; Bulmer-Thomas, *The economic history of Latin America.*

[77] Balassa, 'The process of industrial development'; Fajnzylber, *La industrialización trunca.*

inflation. It became more expensive to step up efforts for import substitution industrialization, which forced Brazil to increase its foreign debt. As long as international credits were readily available and cheap, this strategy worked relatively well. The first oil price shock in 1973 even increased the availability of inexpensive credit as international banks were flooded with so-called petrodollars. But as the 1970s progressed, the international scenario became more unfavourable for this strategy. First, prices of the material and capital inputs needed to pursue import substitution projects increased. Second, the capital-exporting countries raised interest rates to deal with galloping inflation and the tight monetary policy of the Federal Reserve by the time of the second oil crisis in 1979–82, coined the Volcker Shock. The compound effect of these two factors made Brazil debt prone and therefore vulnerable to repercussions in the world markets for financial capital. Awareness of this mounting peril forced General Figueiredo's administration to introduce an economic package of hard measures at the end of 1979. This package of austerity policies coincided with an international slump and led to a recession in 1981–3. On top of that, the debt crisis that erupted in August 1982 after Mexico defaulted on its sovereign debt caused a 'virtual closing of international markets to finance the Latin American debt'.[78] Brazil fell into the hands of the International Monetary Fund (IMF) in December 1982 and Figueiredo's administration was required to pursue additional austerity programmes.

The turmoil in the early 1980s led to a reorientation in economic policies. In keeping with the spirit of the time there was a shift away from protectionism and state regulation and towards pro-market policies. Strong commercial and financial openness went hand in hand with a model oriented towards the export of traditional primary goods.[79] On the one hand, this reorientation, along with the austerity programmes, brought down the fiscal deficit and the current account deficit. On the other hand, neither the policy reorientation nor the austerity programmes, notably the *Cruzado Plan* in 1986 but also several others, managed to suppress the high inflation rates that continued to plague Brazil until the mid-1990s.[80] The failure to stem inflation is often explained by the ineffectiveness of monetary policies and the high degree of indexation. Annual inflation rates averaged 448 per cent per year between 1980 and 1994. Moreover, the adjustment programmes hurt the real economy badly. Capital formation was thwarted, and GDP per capita rates fell significantly. The structural transformation that followed was detrimental to the manufacturing sector, and in particular the sectors that produced capital goods and durable consumer goods.[81] Brazil began to suffer from deindustrialization by the mid-1980s (see table 1). McMillan et al. have presented evidence of a growth-reducing structural change in the aggregate, as manufacturing workers migrated to less-productive, mostly service sectors.[82]

The debt crisis and the macro-economic turmoil of the early 1980s brought the era of convergence to an inglorious end. The 1970s marked the last instance of Brazilian convergence with the United States. Our time series evidence suggests that labour productivity in manufacturing ceased to grow. Since the United States has continued growing apace, as well as enjoying a temporary spurt between 1995 and 2004 associated with the information and communications technology (ICT) revolution, the gap between the two countries has widened considerably. In 2010, the ratio

[78] Baer, *The Brazilian economy*, p. 86.

[79] Yet, this shift in policy stance was not as abrupt and complete as we are often led to believe; the transition to openness in trade policy matters did not occur until the mid-1990s, and Brazil remains a highly protectionist country: see Kume, Piani, and Sousa, 'A política brasileira'.

[80] Ayres et al., 'The history of Brazil'.

[81] Alston et al., *Brazil in transition*, chs. 4–5; de Castro, 'Privatição'.

[82] McMillan et al., 'Globalization'.

even reverted to the same magnitude as in the 1910s, the beginning of our period of study. The long period of stagnation also includes a surge in the 2000s, during Lula's twin presidencies, when growth rates in GDP per capita were respectable, causing grounds for optimism. Considering that the bonus from the manufacturing sector was almost zero, the short-lived economy-wide growth of the 2000s was probably attributable to the commodity boom in the world market. Growth was driven by external factors that were short lived by nature rather than domestic factors that favoured a sustainable acceleration in productivity; in other words, Brazil was growing without progressing.

Structural transformation within the industrial sector does not explain the Brazilian convergence failure since 1980. Many previously protected industries could not meet the challenge from foreign competition as high tariff levels and other protectionist measures gave way to openness in the 1990s. Did deregulation and dismantling of tariffs bring about a structural transformation in which competitive and productive industries survived, adding impetus to growth in productivity? The evidence suggests not. Aldrighi and Colistete have shown that the gloomy record of productivity in manufacturing as a whole in the 1990s and 2000s is attributable to lacklustre performance within industries.[83] The structural component does not explain stagnation. Moreover, Gomes, Pessôa, and Veloso have shown that total factor productivity, which increased until the mid-1970s, declined in the 1980s.[84] These results convey a worrisome message, since the within-industry component identifies the leverage that arose from education and technological changes; in sum, most of the dynamics that we often associate with manufacturing. Economic growth in Brazil may therefore no longer be driven by spillover effects from manufacturing. A possible explanation is that protection had also been given to high-tech industries, so the path towards openness and deregulation also swept away those industries that had technological capabilities, invested in research and development, and offered important linkages to other sectors.

To sum, Brazil's comparable productivity record does not offer either a for or against argument for import substitution industrialization. In defence of the strategy, the verdict on the post-Second World War decades of state-led development is disproportionately coloured by the debt crisis of the early 1980s and the unimpressive growth rates achieved in the period since then. This gloomy context has meant that scholars are more inclined to emphasize shortcomings than accomplishments. With hindsight, it is less likely that scholars would have levelled such damning criticism against import substitution industrialization if Brazil had continued to follow the growth track of the previous decades in the 1980s and 1990s. In fact, all we know with certainty is that the two episodes of dramatic convergence, in the 1950s and the 1970s, coincided with the peaks of state-led development. Our result has laid that fact bare. Additionally, by the late 2010s, the falling behind in manufacturing productivity levels had taken place over a period of four decades since the heydays of import substitution. This considerable time span begs the question whether the two phenomena, state-led development and divergence, are intrinsically connected. As the timeframe expands, it becomes far-fetched to lay full blame for the many hardships in contemporary Brazil on state-led development prior to 1980.

However, our conclusions are of course always affected by the actual course of events. Industry ceased to develop after 1980, and with this detrimental record in mind, an equally persuasive interpretation is that the model of import substitution industrialization carried its own seed of destruction. The inward-looking strategy was not only the victim of the debt crises, but it might also have been responsible for it. For an important constraint of the manufacturing industry was

[83] Aldrighi and Colistete, 'Industrial growth'.

[84] Gomes, Pessôa, and Veloso, 'A evolução'.

the failure to compete with exports in the world market. Three properties of exports are relevant to explain the Brazilian failure to sustain the productivity growth rates of the pre-1980 convergence era. First, exports of manufactured goods could have made it possible to avoid serious debt overhangs, reducing the country's vulnerability to international capital markets. Second, exports have an indirect effect on growth by inducing investment because they permit long-run capital imports (foreign saving), both financial and physical (foreign investment goods). Exports therefore could have paved the way for a sustainable investment-led growth path associated with the neo-classical growth model.[85] Third, exports should preferably be tailored towards those products for which there is growing demand. In Scandinavia in the late nineteenth century, as well as in East Asia in the latter half of the twentieth century, the composition of exports shifted towards a variety of manufactured goods for which there was rising demand in the growing world market. Brazil, meanwhile, remained stuck with exports of a few staple goods based on the supply of natural resources, the demand for which declined relatively in the world market.[86] Heavily protected industries were compelled to borrow from abroad to keep growing. The Volcker Shock of the early 1980s, which dried up the funds for capital investment, brought down the curtain on the previous model of debt-led industrialization. Brazil has since struggled with limited success to embark on a different course of development, which has had an adverse effect on productivity growth rates in manufacturing.

V

This paper has provided a detailed comparison of Brazilian labour productivity in manufacturing with that of the United States between 1912 and 2019. It has established a new productivity benchmark for 1949 on the basis of wholesale prices, and then compared it with previously established benchmarks for 1975, 1985, and 2005. Our new benchmark indicates that Brazilian labour productivity in manufacturing was about one-fifth that of the United States in the late 1940s, compared with the benchmark for 1975, when Brazil was about to approach half the US level. This is an impressive record of convergence, since only a handful of developed countries had achieved higher levels relative to the United States in the 1970s. Our time series projection confirms this narrowing of the Brazilian/US productivity gap. The time series projection back to 1912 also shows that the Brazilian to US labour productivity ratio had risen from about 10 per cent to 25 per cent by 1950. The additional narrowing of the gap occurred mainly in the 1950s and 1970s, two decades that are associated with massive state-led efforts to modernize Brazilian infrastructure and foster import substitution industrialization. Meanwhile, the impressive level of productivity attained by the late 1970s stagnated in the early 1980s in the wake of macro-economic debacles culminating in the debt crisis in 1982. Labour productivity in manufacturing stopped growing amidst rampant inflation and structural transformations that favoured industries which used natural resources intensively. In fact, towards the end of the investigated era in the early 2010s, Brazil had come full circle: comparative productivity had reverted to the same level as in the 1910s. This sequence of impressive convergence initially, followed by lamentable divergence, clearly stands out in our sample of developed and less-developed countries.

Our empirical record has implications for two previous contributions to the convergence debate. First, the Brazilian experience shows that the comparative level of productivity in

[85] Taylor, 'On the costs'.

[86] Álvarez, Bértola, and Bohlin, 'Trade specialization'.

a less-developed country that suffers from an abysmal productivity gap relative to leading countries is inclined to change in tandem with industrialization and technological development. The manufacturing industry is the locus and propelling engine of properties that spill over to growth in the aggregate. In this respect, our results challenge previous studies that downplay the importance of manufacturing in overall income convergence. Second, the boom-and-bust productivity pattern of Brazilian manufacturing also reveals that catching up in manufacturing does not occur unconditionally, as some recent contributions have suggested. This finding questions the argument that deindustrialization is the foremost convergence obstacle for less-developed countries in recent decades. Usually, deindustrialization is the outcome of the dynamics of technological changes. We show that the problematic feature of Brazilian manufacturing is lagging behind in comparative productivity levels and not just in deindustrialization.

ACKNOWLEDGEMENTS

Previous versions of this paper have been presented at conferences in Lund, Uppsala, Gothenburg, Stellenbosch, and Montevideo. We thank the participants for useful suggestions. In addition, we would like to thank Renato Colistete, Dante Aldrighi, Luis Bértola, Jakob Molinder, Thales Pereira, Evelyn Prado, editor Giovanni Federico, and three anonymous referees. The usual disclaimer applies. Svante Prado acknowledges financial support from Riksbankens Jubileumsfond (P13-0109:1) and Jan Wallander and Tom Hedelius Foundation (W2009-0161:1; P2013-0003:1).

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How to cite this article: Lara, C. and Prado, S., 'From boom to gloom: Brazilian labour productivity in manufacturing relative to the United States, 1912–2019', *Economic History Review*, (2022), pp. 1–31. https://doi.org/10.1111/ehr.13228.