Why Did Brazil Deindustrialize So Much? An Empirical Investigation*

Edmar L. Bacha[†] Victor S. Terziani[‡] Claudio M. Considera[§] Eduardo A. Guimarães[¶]

This version: 07/13/2024

Abstract

In constant prices, the GDP share of manufacturing in Brazil fell from 14.7% in 1995.1 to 9.1% in 2022.1, a reduction of 5.6 pp, or 38%. This paper investigates possible causes of such sharp deindustrialization. We consider three hypotheses. The first is that Brazil's deindustrialization is a case of the Dutch Disease; the second is premature deindustrialization; the third is that Brazil's industry would be a peculiar case of Baumol's low-productivity-growth disease. We discuss the evolution of Brazil's GDP manufacturing share on a quarterly basis from 1995.1 to 2022.4, as well as its possible determinants according to these three hypotheses. The econometric analysis reveals the significance of both the Dutch Disease and the premature deindustrialization hypotheses but suggests that falling productivity was the main determinant of Brazil's deindustrialization.

Key words: Baumol's disease, Brazil, Dutch disease, OECD, premature deindustrialization

JEL codes: O14, O54, Q02

*Submitted for publication in a special issue of Metroeconomica on "Lance Taylor: reconstructing macroeconomics and contributions to development economics", edited by Laura Carvalho and Michalis Nikiforos.

[†]Instituto de Estudos de Política Econômica/Casa das Garças. Av. Pe. Leonel Franca 135. 22450-000, Rio de Janeiro, RJ, Brazil. ebacha@iepecdg.com

[‡]Instituto de Estudos de Política Econômica/Casa das Garças. Av. Pe. Leonel Franca 135. 22450-000, Rio de Janeiro, RJ, Brazil. vhsterziani@iepecdg.com.br

[§]Instituto Brasileiro de Economia, Fundação Getúlio Vargas. Rua Presidente Carlos de Campos 417. 22231-080, Rio de Janeiro, RJ, Brazil. claudio.considera@fgv.br

[¶]Centro de Estudos para Integração e Desenvolvimento (Cindes). Rua Jardim Botânico 635, suite 906. 22470-050, Rio de Janeiro, RJ, Brazil. eaaguimaraes@gmail.com

1 Introduction[1]

In the honored Harvard tradition of Simon Kuznets and Hollis Chenery, Lance Taylor wrote his Ph.D. thesis on the patterns of structural change across countries and through time (Taylor, 1967). The analytical chapters of his thesis were the object of his first solo academic paper (Taylor, 1969). Concurrently, Hollis Chenery and Lance Taylor established the benchmark for the modern study of patterns of change in the structure of production as income levels rise (Chenery & Taylor, 1968). Their paper brought together evidence from historical studies of advanced countries, comparisons of countries at different economic levels, and, innovatively, time series for underdeveloped countries, to establish similarities and differences across countries and through time in changes in industrialization patterns as development proceeds.

Chenery and Taylor classified 42 developing countries according to their deviation of the proportions of increase in primary production and industry from the "normal" determined by their regression equations. They found that Brazil was among the countries with a normal proportion, according to its size and income level.

In the Chenery and Taylor tradition of structural change analysis, this paper investigates alternative hypotheses about Brazil's sharp deindustrialization experience from 1995 to 2022. In constant prices, Brazil's GDP share of manufacturing fell from 14.5% in the first quarter of 1995 to 9.1% in the first quarter of 2022, a reduction of 5.4 pp, or 37%.

We consider three hypotheses. The first is that Brazil's deindustrialization is a case of the Dutch Disease, a consequence of a sustained increase in the revenues of natural resource sectors. The presumed mechanism is that while natural resource revenues increase, Brazil's currency appreciates compared to foreign currencies. This results in the country's manufacturing exports becoming more expensive for other countries to buy while imports become cheaper, altogether rendering home manufacturing less competitive.

The classic economic model describing Dutch Disease is by Corden and Neary (1982). Bacha (2013) estimates that the external bonanza generated by terms of trade increases and foreign capital inflows reached over 9% of Brazil's GDP between 2005 and 2011. He parametrizes a simple macroeconomic model in the spirit of Corden and Neary to conclude that this external bonanza could entirely explain Brazil's deindustrialization in the period. Bresser-Pereira (2010) collects five other papers analyzing Brazil's deindustrialization

[1]We are indebted to Afonso Bevilaqua, William Cline, Haishan Fu, Bhaskar Kalimili, Luiz de Mello, Mario Mesquita, Eric Metreau, Antonio Nucifora, Henry Pourchet, José-Guilherme Reis, Ethan Schein, Thiago Vieira, José-Eustaquio Vieira Fo., and Roberto Zagha for help with the data. We thank Marcelo C. Medeiros for comments on an earlier version and Fernando Veloso for comments and help with Brazil's productivity data.

from the perspective of the Dutch Disease.

The second hypothesis is premature deindustrialization: a displacement of economic activity towards non-manufactures, mainly services, alongside a similar trend in more advanced economies—as the GDP share of manufacturing typically follows an inverted U-shape path during development. The term premature–perhaps first used by Dasgupta and Singh (2006) and Palma (2005) and made famous by Rodrik (2016)–is because, in the past, countries with per capita incomes at Brazil's level were still industrializing instead of experiencing deindustrialization.

Palma (2005) expands the concept of Dutch Disease. He uses it as a case of premature deindustrialization, encompassing not only natural resource booms but also the development of export-service activities, mainly tourism and finance, and changes in economic policy (from import substitution industrialization to trade and financial liberalization). In this paper, we stick with the traditional concept of Dutch Disease.

The third hypothesis is that Brazil's industry would be a peculiar case of the so-called Baumol's disease. Baumol (1967) asserts that high-productivity-growth sectors (such as manufacturing in the U.S.) tend to shrink, and laggard sectors (such as services in the U.S.) tend to grow as a share of GDP in current prices. Using industry data for the 1948-2001 period, Nordhaus (2008) investigates Baumol's disease for the U.S. economy. He finds that technologically stagnant sectors (primarily services) had declining relative real outputs. As we will show in the next section, this is also the case in Brazil, except that the technologically stagnant sector is manufacturing. Indeed, Veloso, Matos, Barbosa Filho, and Peruchetti (2024) document that, in Brazil, manufacturing had the lowest labor productivity growth in the 1995-2023 period among the twelve activity sectors considered in the national accounts. This peculiarity (the causes of which still demand explanation) would tend to generate a declining share of manufacturing in GDP at constant prices.

Brazil's deindustrialization–understood as a continuous decline in the GDP share of manufacturing in constant prices–probably dates from the mid-1970s (cf. Bonelli, Pessoa, & Matos, 2013), thus much earlier than the initial year of our analysis, which is 1995. We started in 1995 because we needed quarterly data to generate enough observations for our time series analysis and a consistent set of quarterly national accounts dates from this year. Moreover, Brazil's official statistics body (IBGE) significantly revised the national accounts in 1995, and figures from previous years are not necessarily comparable with those from this date onwards.

Empirical studies of Brazil's deindustrialization are plenty. For example, books by Bacha and de Bolle (2013), Barbosa, Carvalho, Marconi, and Pinheiro (2015), Bresser-Pereira (2010), Carneiro (2002), Carvalho (2010), Holland and Nakano (2011), Morceiro

(2012). And papers by Bonelli et al. (2013), Bonelli and Pinheiro (2016), Campelo Jr. and Sales (2011), Cano (2015), Carvalho and Kupfer (2011), Considera and Trece (2022), Drach (2016), Hiratuka and Sarti (2017), Liboreiro (2021), Maia (2020), Morceiro (2018), Morceiro (2021), Morceiro and Guilhoto (2023), Morrone, Giovanini, and Berni (2022), Nassif (2008), Nassif, Bresser-Pereira, and Feijó (2017), Oreiro and Feijó (2010), Radaelli and Galetti (2014), Ricupero (2005), Souza and Silva (2021), Torres and Cavalieri (2015), Vergnhanini (2013).

We are unaware of any time-series econometric analysis of the type we propose here, but Marconi and Barbi (2011) are a related paper. They estimate panel regressions for the 1995-2007 period, with the GDP shares of 28 manufacturing sectors as dependent variables, and as independent variables lagged values of the dependent variables, per-capita GDP and its square, effective real sectoral exchange rates, GDP shares of gross investment rates, shares of imported inputs in the sector's intermediate consumption, among others. Their results confirm that the GDP shares of manufacturing sectors are strongly autoregressive and follow an inverted-U-shaped path with economic growth, but otherwise, they are not very conclusive.

In the next section, we discuss the evolution of Brazil's GDP manufacturing share quarterly since 1995 and its possible determinants according to the three hypotheses. We display the evolution of manufacturing shares both in current and constant prices. Still, in the econometric analysis, we restrict our attention to real magnitudes, as nominal ones conflate movements in quantities and prices, which are best kept distinct when trying to understand patterns of structural changes and their determinants. Also, we do not provide an econometric analysis of the evolution of Brazil's manufacturing employment share because a consistent series for this variable is available quarterly only from 2012 onwards.

Section three performs econometric tests of the hypotheses about the causes of Brazil's deindustrialization. Section four collects conclusions. An Appendix describes time-series econometric tests. A Data Supplement contains all data we used, with their sources specified.

2 Deindustrialization and its interpretations

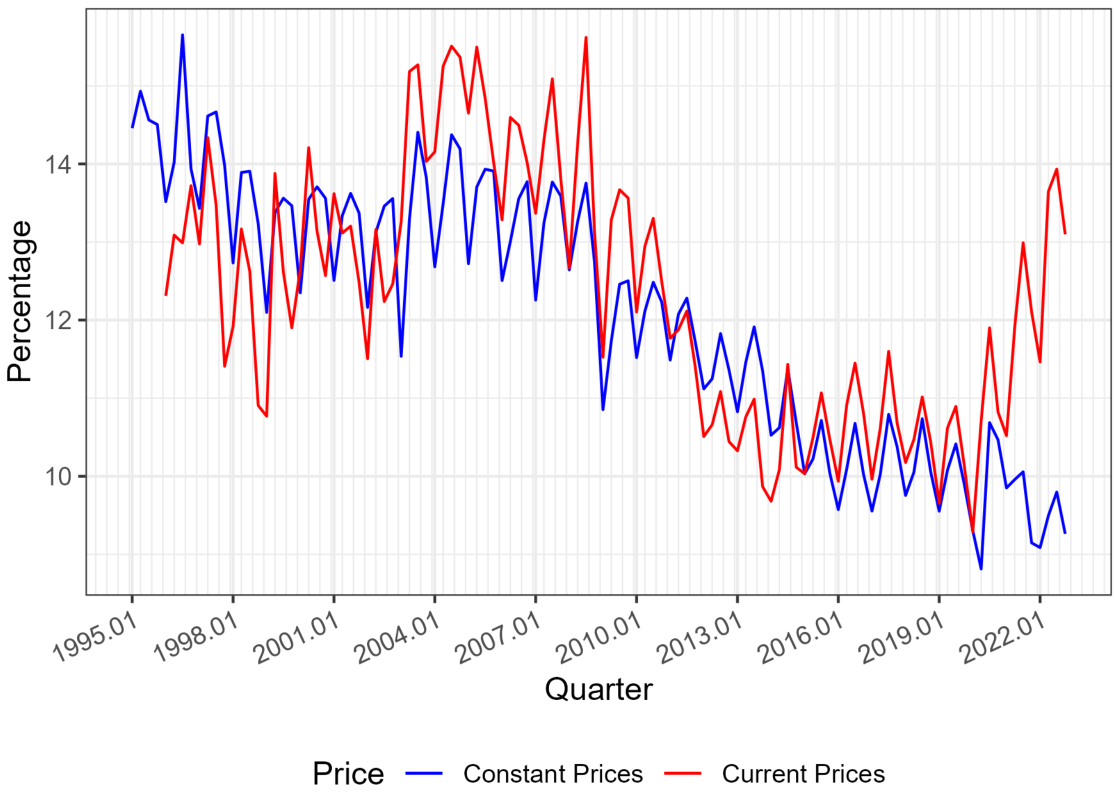
We extract quarterly data on Brazil's industrialization rates from the national accounts: the GDP share of manufacturing in constant prices from 1995.1 to 2022.4 and current prices from 1996.1 to 2022.4. These are shown respectively as the blue and orange lines in Figure 1.

Both series have a marked seasonal pattern within the year, with a peak in the third quarter and a through in the first quarter—more on this in section three. In the following, we make intertemporal comparisons, always taking the first quarter as a basis.

Brazil's industrialization rate in current prices starts at 12.3% in 1996.1 and arrives at a low of 9.3% in 2020.1, for a total deindustrialization of 3 pp, or 24%. In the early years of the period, there was some reindustrialization in current prices, as the GDP share of manufacturing rose from 12.3% in 1996.1 to 14.6% in 2005.1. The industrialization rate in current prices changes little from 2005.1 to 2008.1, when it starts a sharp descent to 9.7% in 2014.1, a value around which the series stabilizes through 2020.1. After this, the current price series sharply increases and ends at values like those at the beginning of the series. The reindustrialization surges from 1996 to 2005 and from 2020 to 2022 are probably associated with the substantial devaluation of the Brazilian currency in these periods, as indicated in Figure 3: manufacturing products are tradable goods, whereas most of GDP comprises non-tradable services. A currency devaluation raises the prices of tradables relative to non-tradables, thus increasing the GDP share of manufacturing in current prices.

Thus, in current prices, Brazil's deindustrialization seems to have occurred in the six-year interval from 2008 to 2014.

Figure 1: Brazil's Industrialization Rates in Current and Constant Prices, 1995.1-2022.4



Such is not the case with the GDP share of manufacturing in constant prices, which matters for our empirical analysis. As the blue line in Figure 1 shows, Brazil's deindustrialization occurs in constant prices nearly throughout the period. In 2015.1 prices, the GDP share of manufacturing falls from 14.5% in 1995.1 to 9.1% in 2022.1, a reduction of 5.4 pp, or 37%.

2.1 The Dutch Disease

According to the Dutch Disease hypothesis, Brazil's deindustrialization would result from increased natural resource revenues. Different indexes might describe the strength of natural resource revenues, but the terms of trade (i.e., the ratio between export and import goods prices) are often used in Brazil. This is so because Brazilian exports are, by and large, primary products, while its goods imports are mostly manufactured products.

Figure 2, with data from Funcex [Fundação Centro de Estudos do Comércio Exterior], displays the evolution of Brazil's terms of trade from 1995.1 to 2022.4, with 2015.1 = 100[2]. The graph illustrates the ups and downs of this variable, with a long upswing from 1999 to 2011 and an upward drift for the whole series. Visually, at least, the terms of trade movements roughly coincide with the deindustrialization in constant prices that occurred in the period.

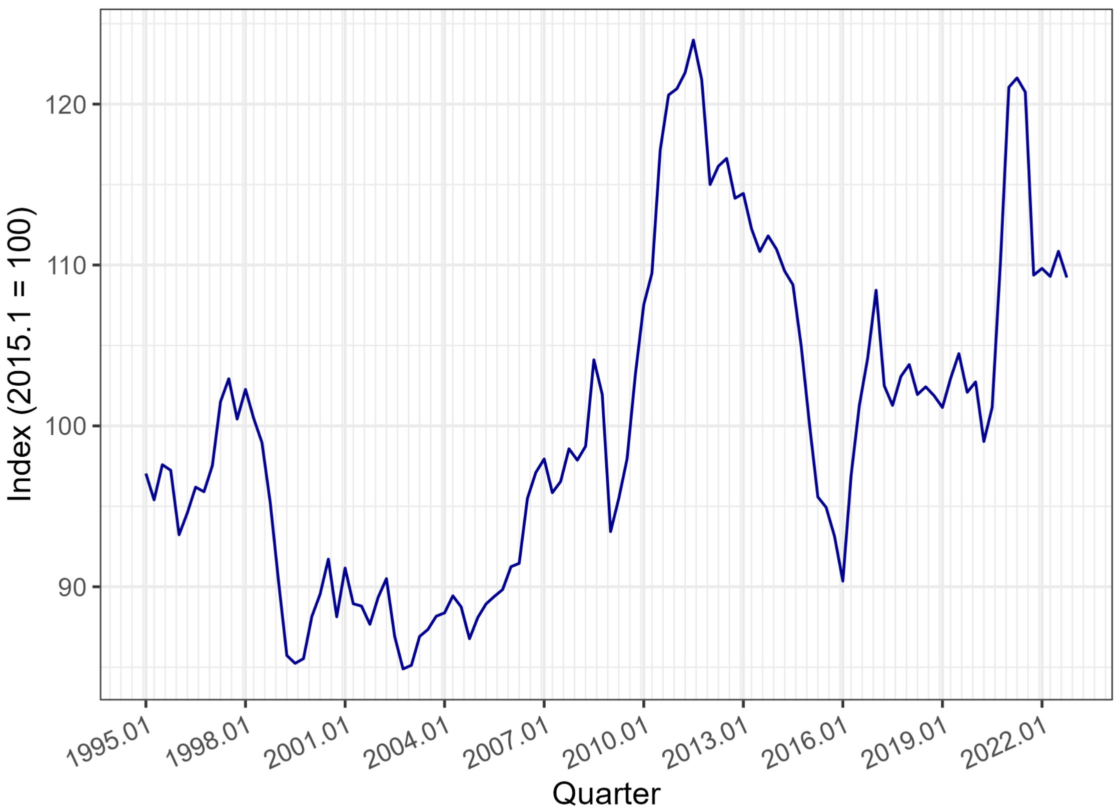
The Dutch Disease hypothesis does not postulate a direct relationship between the terms of trade and deindustrialization, as there is an intervening variable, namely, the real exchange rate. Supposedly, an improvement in the terms of trade appreciates the real exchange rate, and this appreciation crowds out domestic manufacturing. However, other variables affecting the real exchange rate may influence its impact on industrialization rates.

We analyze the behavior of this variable using the real exchange rate of the Real vis-à-vis the U.S. dollar calculated by Brazil's Central Bank[3]. The reasons are that the prices of exports and imports entering the terms of trade are in U.S. dollars; more to the point, many traded goods, particularly commodities, have their prices set in U.S. dollars, while about 90% of Brazil's trade is denominated in this currency.

[2]We thank Henry Pourchet from Funcex for this data.

[3]The price indexes to calculate the real rates are the IPCA for Brazil and the CPI-U for the U.S. We thank Tiago Vieira, from Brazil's Central Bank, for this data.

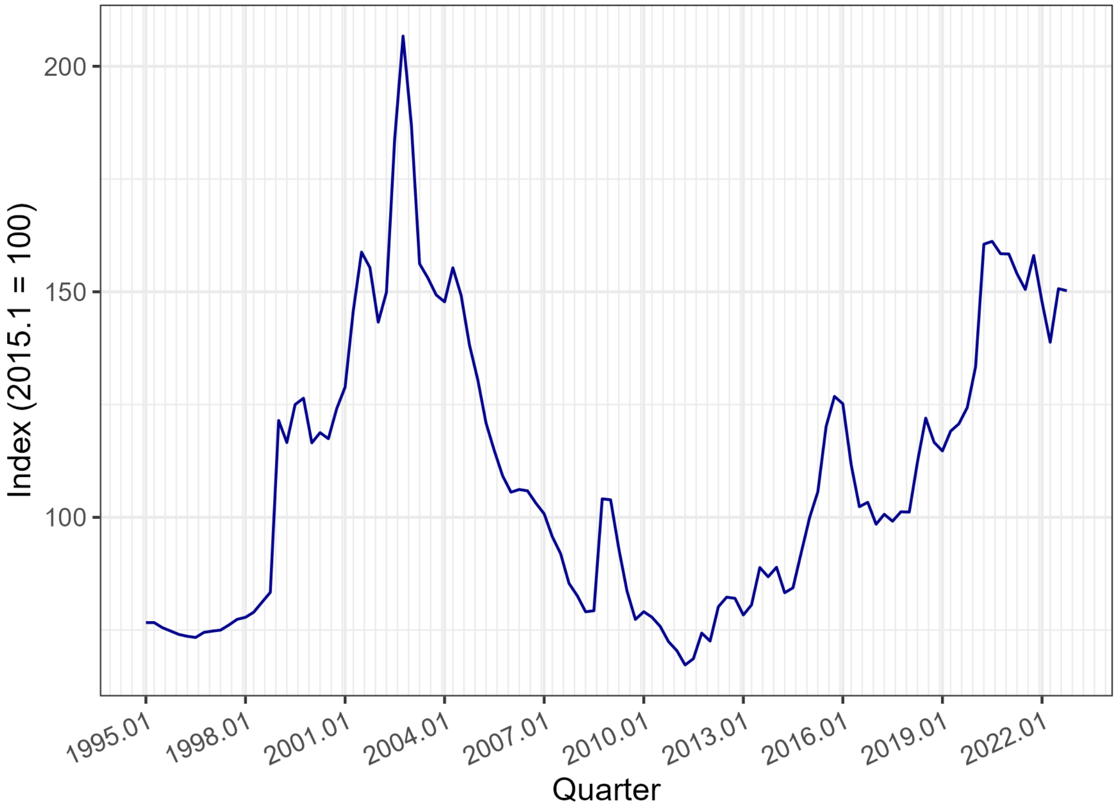
Figure 2: Brazil's Terms of Trade, 1995.1 - 2022.4 (2015.1 = 100)



The volatile behavior of the Real/USD real exchange rate from 1995.1 to 2022.4 (with 2015.1 = 100) is displayed in Figure 3 (higher levels indicate a depreciation of the Real/USD rate). There is a relative constancy during the managed exchange rate period from 1995.1 to 1998.4. There follows a period of sharp depreciation culminating in 2002.3 under the so-called Fear of Lula effect. Sebastian Edwards' (2002) op-ed in the Financial Times of August 4, 2002 ("Brazil's only hope of avoiding collapse") is an illustration of financial market participants fear that the ascension of left-leaning Luiz Inacio Lula da Silva to Brazil's presidency would lead the country to default on its public debt.

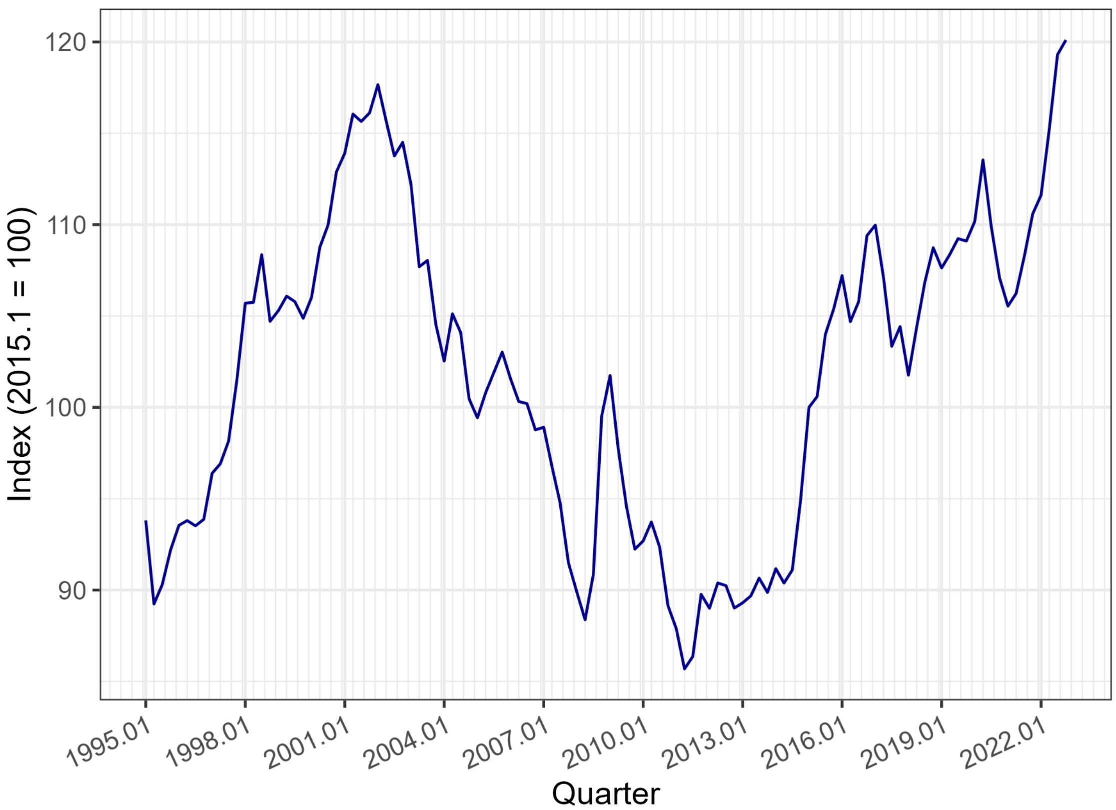
From 2003.1 to 2011.2, Brazil's currency experienced a sharp real appreciation, in line with the China-induced commodity boom. This was followed by a depreciation trend until the end of the period. We conclude that the terms of trade have been an ingredient, but other factors undoubtedly influenced the real exchange rate in the period.

Figure 3: Real/USD Real Exchange Rate, 1995.1-2022.4 (2015.1=100)



One candidate is the strength of the U.S. dollar in the world economy, as depicted in Figure 4–this is the U.S. Fed trade-weighted real broad dollar index, the real exchange rate of a basket of currencies vis-à-vis the U.S. dollar, with 2015.1 = 100 (higher levels indicate U.S. dollar appreciation). This variable does not display a clear tendency in the period. Still, its cyclical behavior resembles the Real/USD rate: it appreciates from 1995 to 2001, depreciates through 2011, and appreciates again through 2022.

Figure 4: Real Broad Dollar Index, 1995.1-2022.4 (2015.1=100)



In the econometric analysis of section three, we'll use the terms of trade and the real Real/USD exchange rate as alternative explanatory variables to capture the Dutch Disease effect on deindustrialization.

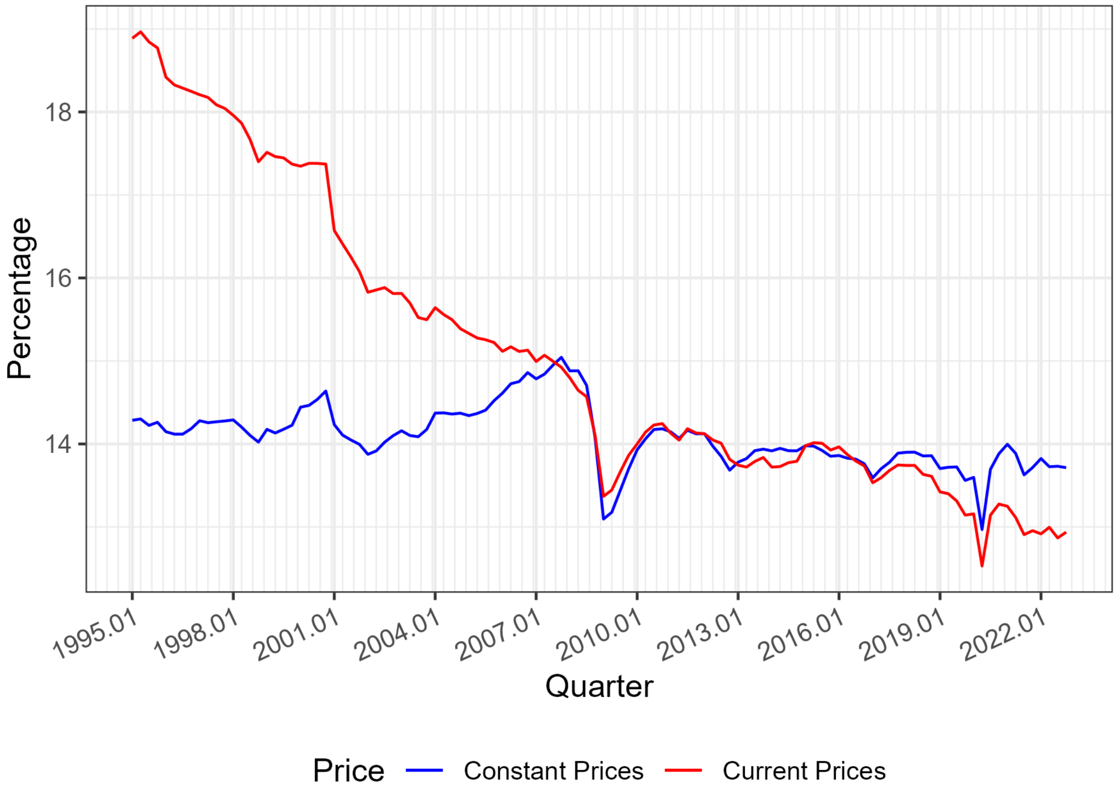
2.2 Premature deindustrialization

To deal with the premature deindustrialization hypothesis, we consider the evolution of industrialization rates in the OECD (Organisation for Economic Co-operation and Development], that is, the GDP share of manufacturing in the OECD in current and constant prices, as presented by Unido [United Nations Industrial Development Organization]. This group of primarily high-income countries is not affected by the Dutch disease (except marginally because of the presence of Australia, Chile, New Zealand, and Norway). The behavior of its manufacturing sector is undoubtedly representative of the rise of the service economy and the emergence of China as a manufacturing powerhouse, which are factors in principle negatively affecting the industrialization rate in advanced countries.

We ask whether deindustrialization in the OECD offers a reasonable explanation for deindustrialization in Brazil. If so, a broader international phenomenon besides the Dutch Disease would be behind Brazil's deindustrialization. As Brazil has a per capita income of about 1/3 of the OECD, this correspondence would indicate a case of premature deindustrialization.

Figure 5 shows the OECD industrialization rates in current (orange line) and constant 2015.1 prices (blue line) for 1995.1-2022.4. The UNIDO Databases present data on OECD industrialization rates only annually. We split these figures into quarters using quarterly and annual data for a subset of 20 countries belonging to the OECD. We used the relationships between quarterly and yearly data on industrialization rates in these countries, year by year, to generate the quarterly figures for the OECD. See the Data Supplement for more information.

Figure 5: OECD's Industrialization Rates in Current and Constant Prices, 1995.1 - 2022.4



The OECD's GDP share of manufacturing falls from 1995 to 2022, but the series in current and constant prices behave very differently. The orange line in Figure 5 shows that, in current prices, the GDP share of manufacturing falls continuously and very substantially: it starts at 18.9% in 1995.1 and ends at 12.9% in 2022.1. This fall is bigger than Brazil's in current prices.

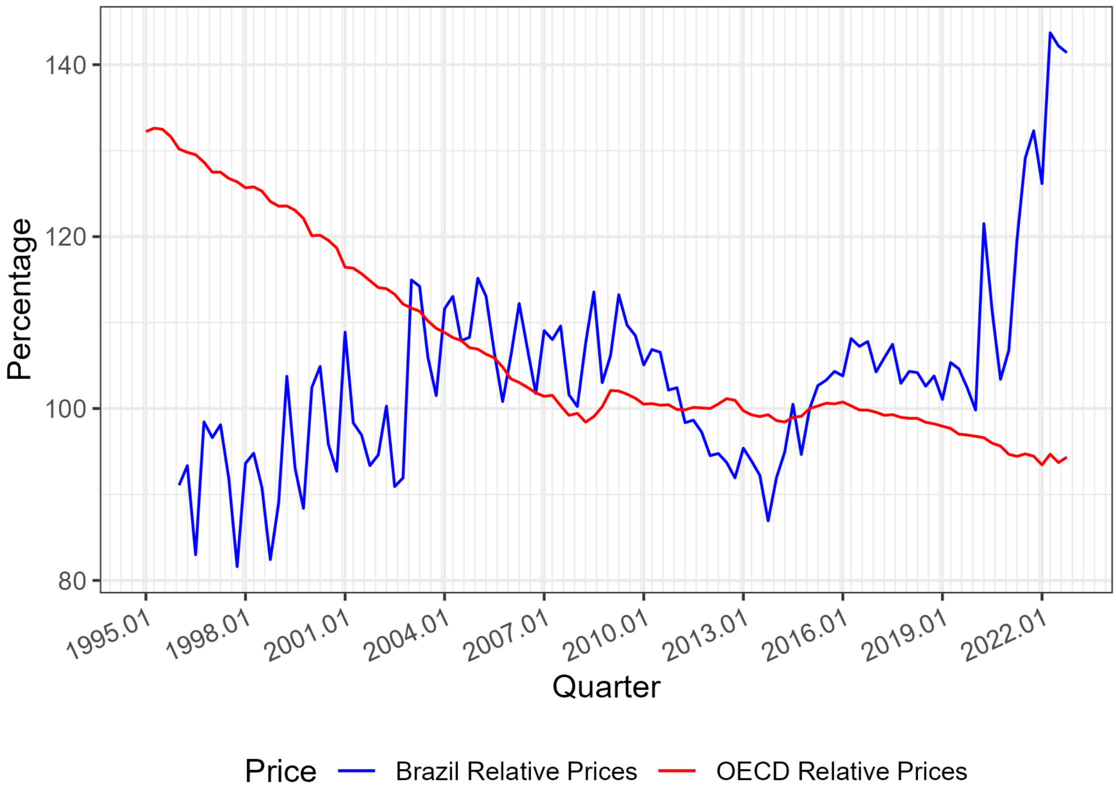
The blue line in Figure 5 shows that the decline in the OECD GDP share of manufacturing in constant prices is tiny: from 14.3% in 1995.1 to 13.8% in 2022.1. The blue line is relatively flat, around 14% until 2005.3. It grows to 15% in the following two years, falling to 13% with the 2008 international financial crisis, after which it resumes the initial baseline of nearly 14%.

Given the constant price series behavior, there seems to be little "mature" deindustrialization in the OECD that could explain Brazil's "premature" deindustrialization from 1995 to 2022. We'll take up this question in the next section.

Rodrik (2016), using data from the late 1940s/early 1950s to the early 2010s, did not find a decline in constant-price manufacturing shares in advanced countries and attributed the fall in the current-price share to the higher rate of technical progress in manufacturing vis-à-vis other economic activities—a supply surge that, faced with inelastic demand, caused relative prices to fall. With the addition of a China effect, reducing manufacturing prices even more, this hypothesis seems to explain the behavior of the series in Figure 5.

The orange line in Figure 6 shows that the relative price of manufacturing in the OECD (obtained implicitly by dividing the GDP manufacturing share in current prices by that in constant prices) trended downward from 1995.1 to 2022.4. In Brazil, however, with significant fluctuations, the relative manufacturing price mainly trended upwards in the period, as the blue line shows.

Figure 6: Relative prices of manufacturing, 1995.1 - 2022.4 (2015.1=100)



2.3 Baumol's disease - Brazilian style

This leads us to Baumol's disease. Underlying the original version of this disease is the presumption that manufacturing is a sector with fast relative productivity growth and declining relative prices. Services would comprise the laggard sectors, the relative prices of which would increase with economic growth. The declining trend of manufacturing relative prices in the OECD conforms with this thesis. This does not happen in Brazil, where manufacturing relative prices, if at all, trend upward, not downward.

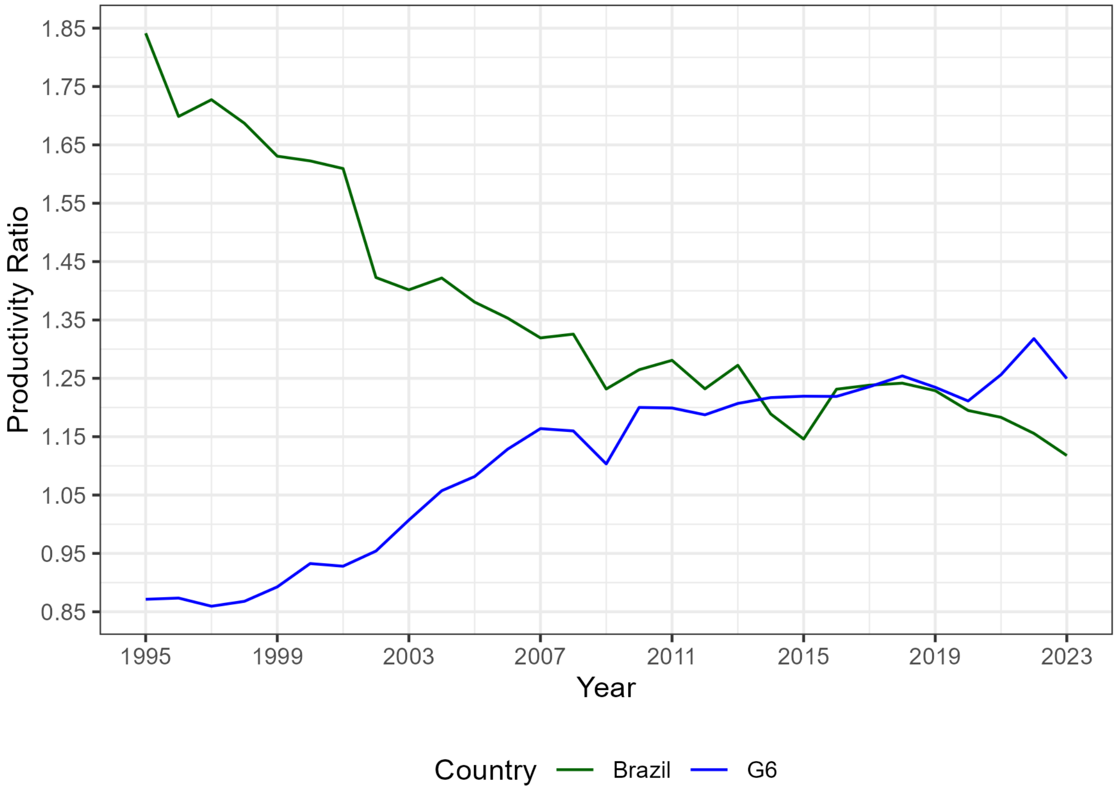
What can be said about the evolution of relative labor productivity in manufacturing? By this, we mean manufacturing real value added divided by the number of employees in manufacturing, as a ratio to real GDP divided by the number of employees in the economy.

For Brazil, in the 1995-2023 period, we have only annual data for this variable. The source is IBGE, with manufacturing value added and GDP in 2021 prices. This data was processed by the Productivity Observatory of IBRE/FGV[4]. We could not obtain an annual series for the OECD and had to settle for a productivity series (in 2015 prices) for the G7 countries minus Canada, a group that we'll denominate G6. See the Data Supplement for the steps involved in constructing this series.

Figure 7 shows the evolution of manufacturing relative productivity in Brazil (green line) and the G6 (blue line) from 1995 to 2023. For the G6, the line has a positive slope: labor productivity in manufacturing grows faster than in the total economy. For Brazil, it is the opposite: the relative labor productivity in manufacturing declines continuously and very substantially. Manufacturing labor productivity was 84% higher than the total economy at the beginning of the period. In the end, this advantage was reduced to 12%. For the G6, labor productivity in manufacturing was 13% lower than the total economy in 1995; in 2023, it was 25% higher.

[4]We are indebted to Fernando Veloso for this data.

Figure 7: Relative labor-productivity in manufacturing: Brazil and the G6, 1995-2023



It is beyond this paper's limits to investigate why manufacturing labor productivity behaved poorly in Brazil. We list four hypotheses that deserve further research:

1. Considera (2017) suggests that the decline in labor productivity was associated with reduced savings and investment rates in manufacturing. Bonelli and Pinheiro (2017) decompose the evolution of labor productivity of 20 manufacturing sectors from 2007 to 2013 and find that the capital-labor ratio fell in most sectors, which explains 30% of the labor-productivity decline in the period. These findings suggest that the hypothesis certainly needs more investigation.

2. A second hypothesis is that low-productivity sectors gained relevance in manufacturing, perhaps because high-productivity sectors faced increased competition from imports or weak domestic demand. Carvalho (2010) performed an empirical study comparing the Brazilian industrial structure with that of other countries to conclude that the country's industry began a specialization process at lower levels of income per capita than other countries. This process was marked by the gain in weight of sectors with less technological sophistication that already accounted for a high share of industrial output. In an empirical analysis of the 1970-2016 period, Morceiro and Guilhoto (2023) identified what they call "normal" deindustrialization in

low-productivity sectors and "premature" deindustrialization in high-productivity sectors. Monteiro and Borghi (2023) find that the GDP share of high-tech manufacturing sectors declined most within manufacturing in the 2000-2018 period. These are significant findings, but in their decomposition of the labor-productivity decline in manufacturing from 2007 to 2013, Bonelli and Pinheiro (2017) conclude that composition changes (i.e., varying shares of value added and employment of 20 manufacturing sectors) had little impact on the evolution of labor productivity in manufacturing.

3. Carneiro (2002), among others, asserts that the penetration of imports would have disrupted domestic manufacturing value chains with adverse effects on output and productivity. The mechanism that would generate this result needs to be clarified. In an econometric analysis of 28 manufacturing sectors in the 1995-2007 period, Marconi and Barbi (2011, p. 68) find a negligible impact on the GDP share of these sectors of the fraction of imports in their consumption of intermediate goods: the contemporaneous effect is positive, while the one-year lagged effect is negative. The algebraic sum of the two coefficients is near zero. In an empirical analysis of the 1995-2011 period, Rios and Araujo Jr. (2013) conclude that it is impossible to explain the negative performance of any Brazilian manufacturing sector based on the evolution of the degree of import penetration. Econometric analyses of the effects of the reductions of tariff and non-tariff barriers to imports in the 1990s concur that these positively affected the total factor productivity of industrial firms. Hay (2001) and Muendler (2004) emphasize the positive effect of the competitive pressure from imports on local firms' adoption of new technologies. Ferreira and Rossi (2003), Schor (2004) and Lisboa, Menezes Filho, and Schor (2010) find that using more efficient imported inputs also increased productivity. Empirical investigations on the impact of trade openness on deindustrialization for large groups of countries arrive at disparate conclusions. In two of their six regressions, Araujo, Araújo, Peres, and Punzo (2021) find a significant negative relationship between trade openness and industrialization rates for a sample of developing and emerging economies. For a similar group of countries, Özçelik and Özmen (2023) find a positive, although not significant, relationship between those two variables. For Latin America, a group more relevant to Brazil, these authors found a statistically significant positive relationship between the GDP manufacturing share and the degree of openness to international trade.

4. Figure 7 shows that, in 1995, the relative manufacturing productivity in Brazil was 84% higher than the economy's mean. In the following years, the relative productivity of manufacturing converged from above towards the economy's mean. In 2023, it was only 12% higher than it. According to the IBRE Productivity Observatory

data (cf. Veloso et al., 2024), this movement was accompanied by a spectacular increase in the productivity of agriculture: it started in 1995 at 22% of the economy's mean to arrive in 2023 at 94% of it. Taken as a group, the relative productivities of the other sectors of economic activity, besides manufacturing and agriculture, remained nearly invariant. The downward trend of the relative productivity in manufacturing was the mirror image of the upward trend of the relative productivity in agriculture. Hence, one might argue that, rather than manufacturing suffering from a peculiar case of the Baumol disease, what happened in Brazil was just an extraordinary surge in agricultural productivity. However, this catch-up hypothesis does not explain why manufacturing productivity not only did not follow the example of agriculture but, on the contrary, declined in absolute terms. Bacha (2024), Menezes Filho and Kannebley Junior (2013), and Rios and Veiga (2022) argue that insufficient exposition to the forces of creative destruction of international trade might be part of the explanation.

3 Regression Results

We proceed in two stages. First, we estimate a regression of the Real/USD real exchange rate (RER) on Brazil's terms of trade and the broad real dollar index for the 1995.1-2022.4 period. We include three dummy variables in this regression: one for 1995.1 to 1998.4, when the exchange rate was managed before starting to float in Jan. 1999; another for 2002.3 to 2003.1, when the fear of Lula was manifest; and a third one for 2020.2 to 2021.4 on account of the COVID crisis.

Next, we use a lagged fitted value of the RER, or else a lagged value of the terms of trade, as independent variables in regressions for the GDP share of manufacturing in Brazil in constant prices (to which we also refer as Brazil's industrialization rate), in the 1996.1-2022.4 period. Preliminary tests indicated which lag of the RER or the terms of trade performed better. These two indices–lagged fitted RER or lagged terms of trade–capture the Dutch Disease effect.

The premature deindustrialization effect is indicated by the coefficient of the GDP share of manufacturing in the OECD in constant prices.

Another regressor is a time trend. This is designed to capture the effect on the industrialization rate of the Brazilian version of Baumol's disease. As discussed in the previous section, in Brazil, this disease has expressed itself as a decline in relative labor productivity in the manufacturing sector. Figure 7 shows that this variable fell nearly continuously from 1995 to 2023. This suggests using a time trend to capture the effect of

Baumol's disease on Brazil's industrialization rate. The time trend also helps to reduce the autocorrelation in the residuals.

As explained, we do not have quarterly data on labor productivity. But even if we did, we couldn't use them directly, as a real value-added ratio equals a labor productivity ratio multiplied by an employment ratio. Instrumental variables for the productivity ratio would need to be used to avoid a spurious regression, and the time trend can be understood as a proxy for these: the correlation coefficient between the relative productivity of manufacturing and time is -0.92.

Four lagged values of the dependent variable are also included in the regressions. This has an economic justification: the industrialization rate is a slow-moving variable, and a statistical one: the lags help to alleviate biases generated by autocorrelation in the residuals.

Finally, there are the seasonal/quarterly dummies, which capture the ups and downs of the industrialization rate within the year.

In the Appendix, we present a series of statistical tests to evaluate the validity of our regressions. The Autocorrelation Functions and Partial Autocorrelation Functions demonstrate the absence of individual residual autocorrelation in our regressions. Along with the results of the Ljung-Box tests, we conclude that there should not be any residual autocorrelation in the regressions, implying that the estimators are consistent. Since the real exchange rate regression does not include lags of the dependent variable as a regressor, residual autocorrelation should not affect the consistency of the estimators in this case.

The Appendix also presents the results of the Engle-Granger cointegration test for all regressions. The Engle-Granger test performs a unit-root test–we use the Augmented Dickey-Fuller (ADF) test–in the regression residuals. They indicate that none of the regressions exhibit integrated residuals, even though all dependent variables are integrated. This provides evidence that the variables are cointegrated and the regressions are not spurious but indicate genuine relationships.

The results of the regressions are summarized in Table 1. The coefficients are all linear, and in the case of the industrialization rate, they indicate short-term effects. In the following, we'll comment on the elasticities derived from the linear coefficients for the RER regression. These are calculated at the mean values of the relevant variables. For the industrialization rate regressions, we'll comment on the short- and long-run effects. The former is expressed directly by the linear coefficients, the latter by these coefficients multiplied by $\frac{1}{(1-z)}$, where z is the sum of the coefficients of the four lagged values of the dependent variable. For example, the value of z in the regression in column (2) of Table 1 is $0.663(= 0.262 + 0.146 - 0.037 + 0.292)$, which yields $\frac{1}{(1-z)} = 2.97$.

Table 2 summarizes the responses of the dependent variables to changes in the independent variables, calculated from regressions (1) and (2) in Table 1.

Table 1: Regression results

	RER	BR Industrialization Rate - Constant Prices	
	(1)	(2)	(3)
Constant	-7.522	-3.057+	-4.390**
	(0.761)	(0.070)	(0.006)
Terms of Trade	-0.736***		
	(<0.001)		
Real Broad Dollar Index	1.878***		
	(<0.001)		
Dummy Managed	-26.756***		
	(<0.001)		
Dummy Lula	49.956***		
	(<0.001)		
Dummy Covid	42.983***		
	(<0.001)		
1st Lag BR Ind.Rate		0.262**	0.257*
		(0.007)	(0.022)
2nd Lag BR Ind.Rate		0.146	0.147
		(0.134)	(0.206)
3rd Lag BR Ind.Rate		-0.037	-0.038
		(0.701)	(0.744)
4th Lag BR Ind.Rate		0.292**	0.289***
		(0.001)	(<0.001)
3rd Lag Terms of Trade		-0.009*	
		(0.038)	
3rd Lag Fitted RER			0.003+
			(0.058)
OECD Ind.Rate		0.563***	0.588***
		(<0.001)	(<0.001)
Time Trend		-0.011**	-0.013***
		(0.005)	(<0.001)
2nd Quarter		0.829***	0.817***
		(<0.001)	(<0.001)
3rd Quarter		1.159***	1.153***
		(<0.001)	(<0.001)
4th Quarter		0.567**	0.563**
		(0.002)	(0.002)
Num.Obs.	112	108	108
R2	0.882	0.960	0.961
R2 Adj.	0.876	0.956	0.958
RMSE	10.79	0.33	1.00

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001
P-Values between parentheses.

Consider first the regression for the real exchange rate (RER) in column (1) of Table 1. As expected, this variable is highly dependent on Brazil's terms of trade, with a coefficient of -0.7 and an elasticity of also -0.7 (the mean of RER is 109.87, and the mean

Table 2: Responses of dependent variables to changes in independent variables calculated from regressions (1) and (2) in Table 1

Percent change* of the real Real/USD exchange rate in response to:		
1% increase in terms of trade		-0.7
1% appreciation of the real dollar index		1.7
Managed exchange rate regime		-24.4
Fear of Lula		45.5
Covid		39.1
Percentage point change of Brazil's industrialization rate in response to:		
	Short-run	Long-run
10% rise in terms of trade	-0.09	-0.27
1 pp rise in OECD ind. rate	0.56	1.67
Plus 1 year (time trend)	-0.04	-0.13

*Calculated at the means of the variables. A positive value indicates depreciation.

of the terms of trade is 100.17). As the terms of trade rise by 10%, the real exchange rate appreciates by 7%. The Real/USD exchange rate is even more dependent on the dollar index, with a coefficient of 1.9 and an elasticity of 1.7 (the mean of the dollar index is 101.67). A 10% rise in the dollar index leads to a 17% depreciation of the Real to the U.S. dollar. This shows that the USD value of Brazil's currency is highly sensible to the dollar's strength in the world economy.

The coefficients of the dummy variables have the expected sign: a 27 pp (or 24%) appreciation during the managed exchange rate period in 1995.1 to 1998.4; a 50 pp (or 46%) depreciation with the fear of Lula in 2002.3 to 2003.1; and a 43 pp (or 39%) depreciation with the Covid crisis in 2020.2-2021.4. The percentage changes are calculated at the mean of the RER, which is 109.87. Such sharp fluctuations reveal the sensitivity of Brazil's currency to domestic and external shocks.

We now consider the two regressions in Table 1 for Brazil's industrialization rate. The only difference in these regressions is that in column (2), the Dutch Disease is captured by the terms of trade, whereas in column (3), it is captured by the fitted RER. It makes very little difference for the coefficients of the other regressors, which variable stands for the Dutch Disease. We'll analyze the coefficients in the regression in column (2) that includes the terms of trade, as this variable was statistically more significant and had a stronger effect on the industrialization rate than the fitted RER. On reflection, this is what we should expect because the RER is affected by the dollar index and domestic and international shocks unrelated to the Dutch Disease.

The Dutch Disease and the premature deindustrialization hypotheses appear statistically significant in the regressions. Consider first the Dutch Disease with its effect measured by the coefficient of the third lag of the terms of trade in the regression in column (2), which is -0.009. At the terms of trade mean (= 100.17), this signifies that a 10% rise in the terms of trade reduces the industrialization rate by .09 pp on impact. This effect needs to be multiplied by $2,97 = \frac{1}{(1-0,663)}$ to obtain -0.27 as the long-run effect of the terms of trade on the industrialization rate. In the long run, a 10% rise in the terms of trade reduces the industrialization rate by 0.27 pp. The effect is relevant.

Changes in the OECD industrialization rate have a stronger impact than the terms of trade (but these changes are little compared to the terms of trade fluctuations). On impact, a 1 pp reduction in the OECD industrialization rate leads to a 0.563 pp reduction in Brazil's industrialization rate. The long-run effect is $0.563 * 2.97 = 1.67$. Thus, in the long run, a 1 pp decrease in the OECD industrialization rate leads to a 1.67 pp reduction in Brazil's industrialization rate. Such a strong effect was already suggested by the data analyzed in section two: Brazil deindustrialized much more than the OECD did in the 1995-2022 period. This sizable effect seems hard to justify purely in the context of the premature deindustrialization hypothesis, which seemingly implies that there would be, at most, a one-to-one correspondence between Brazil's and the OECD's deindustrialization rates. However, even with such a high coefficient, the total long-run impact on Brazil's deindustrialization of the 0.5 pp OECD deindustrialization in the period is only 0.8 pp.

The single most important variable to explain Brazil's deindustrialization is the time trend: according to its coefficient in the regression in column (2) of Table 1, the industrialization rate falls by 0.011 pp each quarter, or 0.044 pp per year–and this is on impact. In long-run equilibrium, the effect on the industrialization rate of moving one year ahead is -0.13 pp ($= 0.044 * 2.97$). Thus, on impact, the time trend would imply a reduction of 1.2 pp ($= 0.044 * 27$) in Brazil's industrialization rate from 1995 to 2022; in the long run, its negative effect would be 3.5 pp ($0.13*27$). This is 65% of the 5.4 pp deindustrialization observed in the period.

Finally, there are the seasonal/quarterly dummies. According to them, the industrialization rate in the 2^{nd} quarter is 0.8 pp higher than in the 1^{st} quarter; in the 3^{rd} quarter, 1.2 pp higher; and in the 4^{th} quarter, 0.6 pp higher. Seasonal changes are very significant within the year. Besides the negative effect on industrial production of collective vacations in the summer months of January and February, the through in the 1^{st} quarter may also be related to IBGE's methodology of computing most of the agriculture output in this quarter. The peak in the 3^{rd} quarter is probably explained by an acceleration in industrial production in this quarter, as sales tend to be higher at the end of the year.

4 Conclusions

We investigate econometrically three hypotheses about Brazil's deindustrialization in the 1995-2022 period: Dutch Disease, premature deindustrialization, and (Brazilian style) Baumol's disease. We capture Dutch Disease through the terms of trade improvement, premature deindustrialization through the evolution of the OECD deindustrialization rate, and Baumol's disease through a time trend. The time trend stands for the nearly uniformly negative evolution of the relative productivity of manufacturing in the period.

By far, Baumol's disease Brazilian style, as captured by the time trend, is the most important factor explaining the deindustrialization in the period. It accounts for 3.5 pp, or some 2/3 of it[5]. The terms of trade also had an impact, as they went up by some 30% over the period. According to our long-run estimates, this led to a decline in the industrialization rate of some 0.8 pp. Thus, Dutch Disease is present in the data, but its total impact is not very big. The OECD deindustrialized little but had a magnified effect on Brazil's deindustrialization. In the long run, it explained 0.8 pp of it. Premature deindustrialization explains part of Brazil's deindustrialization, but no more than the Dutch Disease does. Table 3 summarizes these results.

Table 3: Total long-run effects of independent variables on Brazil's deindustrialization rates 1995-2022

Total variation	**Total effect (pp)**
Baumol's disease: 27y	-3.5
Dutch Disease (ToT): +30%	-0.8
Premature deindustrialization (OECD deindustrialization): -0.5 pp	-0.8
Sum of long-run effects	-5.1
Total Brazil deindustrialization (pp)	-5.2/-5.4
Sources: see text.	

Our findings strongly suggest shifting the narrative focus of deindustrialization from GDP shares to relative productivity. Why did Brazil's manufacturing have such poor relative productivity performance? We did not explore this topic econometrically but listed a few explanations in the Brazilian literature. Some empirical papers suggest

[5]Total deindustrialization was 5.4 pp measured by the difference between the industrialization rates in the first quarters of 1995 and 2022, and 5.2 pp measured by the difference between the average values of the industrialization rates in those years.

an association between industrial productivity loss and higher penetration of industrial imports, which would have disrupted local production chains. However, econometric evidence points in the opposite direction: import liberalization had a causal positive effect on industrial productivity.

The problem might instead be Brazil's industry's insufficient exposure to the creative destruction forces of international trade. Brazil's agriculture experienced a spectacular productivity surge and successfully competes with the U.S. and Canada in world markets, which would give credence to this hypothesis. But other factors are undoubtedly at play, such as relative investment rates and composition changes within manufacturing. Our analysis clarifies that the topic is important enough to warrant further research.

Our econometric exercises uncovered another relevant fact. We found that Brazil's Real/USD exchange rate is indeed much affected by the country's terms of trade, as the Dutch Disease hypothesizes. Nonetheless, other factors mattered more, namely, the strength of the dollar in the world economy and domestic and international shocks, such as the Fear of Lula from 2002.3 to 2003.1 and the Covid crisis from 2020.2 to 2021.4. These other factors muted the effect of the terms of trade increase observed in the period on the course of the inflation-corrected Real/USD exchange rate. This rate fluctuated widely, but since 2011, it has tended chiefly to depreciate. One of our regressions captured a small and only marginally significant positive effect of the exchange rate depreciation on the industrialization rate. We conclude that the exchange rate had little to do with Brazil's deindustrialization from 1995 to 2022.

References

Araujo, E., Araújo, E., Peres, S. C., & Punzo, L. F. (2021). An investigation into shapes and determinants of deindustrialization processes: Theory and evidence for developed and developing countries (1970–2017). *EconomiA*, *22*, 129-143. https://doi.org/10.1016/j.econ.2021.03.001

Bacha, E. (2013). Bonança externa e desindustrialização: uma análise do período 2005-2011. In E. Bacha & M. de Bolle (Eds.), *O futuro da indústria no Brasil: Desindustrialização em debate* (p. 97-120). Rio de Janeiro: Civilização Brasileira.

Bacha, E. (2024). Economic inwardness and stagnation: why does brazil persist? In S. Galiani & C. Winograd (Eds.), *Political economy and economic development: Essays in honor of Adolfo Canitrot.* London: Palgrave/Macmillan. (forthcoming)

Bacha, E., & de Bolle, M. (Eds.). (2013). *O futuro da indústria no Brasil.* Rio de Janeiro: Civilização Brasileira.

Barbosa, N., Carvalho, L., Marconi, N., & Pinheiro, M. C. (Eds.). (2015). *Indústria e desenvolvimento produtivo no Brasil.* Rio de Janeiro: Elsevier.

Baumol, W. J. (1967). Macroeconomics of unbalanced growth: The anatomy of urban crisis. *The American Economic Review*, *57*, 415–426.

Bonelli, R., Pessoa, S., & Matos, S. (2013). Desindustrialização no Brasil: fatos e interpretações. In E. Bacha & M. de Bolle (Eds.), *O futuro da indústria no Brasil: Desindustrialização em debate* (p. 45-79). Rio de Janeiro: Civilização Brasileira.

Bonelli, R., & Pinheiro, A. C. (2016). Auge e declínio da indústria no brasil. In R. Bonelli & F. Veloso (Eds.), *A crise do crescimento no Brasil* (p. 193-220). Rio de Janeiro: Elsevier: FGV/IBRE.

Bonelli, R., & Pinheiro, M. C. (2017). Produtividade da indústria de transformação: desempenho por atividade e tamanho de empresa, 2007-2013. In R. Bonelli, F. Veloso, & A. C. Pinheiro (Eds.), *Anatomia da produtividade no Brasil* (p. 183-209). Rio de Janeiro: Elsevier: FGV/IBRE.

Bresser-Pereira, L. C. (Ed.). (2010). *Doença holandesa e indústria.* Rio de Janeiro: Editora FGV.

Campelo Jr., A., & Sales, S. (2011). Produtividade e competitividade da indústria brasileira de 1996 a 2010. In R. Bonelli (Ed.), *A agenda de competitividade do brasil* (p. 307-321). Rio de Janeiro: Editora FGV.

Cano, W. (2015, dez.). A desindustrialização no Brasil. *Economia e Sociedade*, *21*, 831–851. https://periodicos.sbu.unicamp.br/ojs/index.php/ecos/article/view/8642273 (special issue)

Carneiro, R. (2002). *Desenvolvimento em crise.* São Paulo: Editora UNESP.

Carvalho, L. (2010). *Diversificação ou especialização: uma análise do processo de mudança estrutural da indústria brasileira nas últimas décadas.* Rio de Janeiro: BN-

DES.

Carvalho, L., & Kupfer, D. (2011). Diversificação ou especialização: uma análise do processo de mudança estrutural na indústria brasileira. *Revista de Economia Política*, *31*, 618-637. https://doi.org/10.1590/S0101-31572011000400007

Chenery, H. B., & Taylor, L. (1968). Development patterns: Among countries and over time. *The Review of Economics and Statistics*, *50*, 391-416. https://doi.org/10.2307/1926806

Considera, C. (2017). Produtividade, investimento e poupança no Brasil – 1995-2014 (uma avaliação com base nas Contas Nacionais). In R. Bonelli, F. Veloso, & A. C. Pinheiro (Eds.), *Anatomia da produtividade no Brasil* (p. 241-262). Rio de Janeiro: Elsevier: FGV/IBRE.

Considera, C., & Trece, J. (2022). *À beira da extinção.* Rio de Janeiro. (Unpublished manuscript. FGV/IBRE)

Corden, W. M., & Neary, J. (1982). Booming sector and de-industrialization in a small open economy. *The Economic Journal*, *92*, 825-848. https://doi.org/10.2307/2232670

Dasgupta, S., & Singh, A. (2006, May). *Manufacturing, services and premature deindustrialization in developing countries* (Research paper No. 049). Helsinki, Finland: The United Nations University World Institute for Development Economics Research.

Drach, D. (2016). *Determinantes estruturais do emprego industrial para o período 2003-13: uma abordagem via decomposição estrutural* (Unpublished master's thesis). Universidade Estadual de Campinas.

Edwards, S. (2002). Brazil's only hope of avoiding collapse. *Financial Times*. http://news.ft.com/servlet/ContentServer?pagename=FT.com/StoryFT/FullStory&c=StoryFT&cid=1028185498259&p

Ferreira, P., & Rossi, J. (2003). New evidence from brazil on trade liberalization and productivity growth. *International Economic Review*, *44*, 1383-1405. https://doi.org/10.1111/1468-2354.t01-1-00114

Hay, D. (2001). The post-1990 brazilian trade liberalisation and the performance of large manufacturing firms: Productivity, market share and profits. *Economic Journal*, *111*, 620-641. https://ideas.repec.org/a/ecj/econjl/v111y2001i473p620-41.html

Hiratuka, C., & Sarti, F. (2017). Transformações na estrutura produtiva global, desindustrialização e desenvolvimento industrial no Brasil. *Revista de Economia Política*, *37*, 189-207. https://doi.org/10.1590/0101-31572016v37n01a10

Holland, M., & Nakano, Y. (Eds.). (2011). *Taxa de câmbio no brasil: Estudos de uma perspectiva do desenvolvimento econômico*. Rio de Janeiro: Elsevier.

Liboreiro, P. R. (2021). The drivers of deindustrialization in Brazil (2000-2014): a dynamic hierarchical-structural decomposition analysis. In *Anais do 14º Encontro In-*

ternacional da Associação Keynesiana Brasileira: o Brasil em um mundo em transformação. São Bernardo do Campo, SP: Universidade Federal do ABC. https://www.even3.com.br/anais/akb2021/372655-the-drivers-of-deindustrialization-in-brazil-(2000-2014)--a-dynamic-hierarchical-structural-decomposition-analysi

Lisboa, M., Menezes Filho, N., & Schor, A. (2010). The effects of trade liberalization on productivity growth in brazil: Competition or technology? *Revista Brasileira de Economia*, *64*, 277-289. https://doi.org/10.1590/S0034-71402010000300004

Maia, B. (2020). Há desindustrialização no brasil? um estudo da abordagem clássica e de análises alternativas entre 1998 e 2014. *Economia e Sociedade*, *29*, 549-579. https://doi.org/10.1590/1982-3533.2020v29n2art08

Marconi, N., & Barbi, F. (2011). Taxa de câmbio e composição setorial da produção. In M. Holland & Y. Nakano (Eds.), *Taxa de câmbio no brasil: Estudos de uma perspectiva do desenvolvimento econômico* (p. 31-75). Rio de Janeiro: Elsevier.

Marconi, N., & Rocha, M. (2012). Taxa de câmbio, comércio exterior e desindustrialização precoce – o caso brasileiro. *Economia e Sociedade*, *21*, 853-888. (special issue) https://doi.org/10.1590/S0104-06182012000400007

Menezes Filho, N., & Kannebley Junior, S. (2013). Abertura comercial, exportações e inovações no brasil. In F. Veloso, P. C. Ferreira, F. Giambiagi, & S. D. A. Pessôa (Eds.), *Desenvolvimento econômico: uma perspectiva brasileira* (p. 405-425). Rio de Janeiro: Elsevier.

Monteiro, J., & Borghi, R. (2023). A desindustrialização brasileira à luz da tradição estruturalista: uma análise multissetorial (2000-2018). In *Anais do xvi encontro internacional da associação keynesiana brasileira.* https://even3.blob.core.windows.net/anais/677234.pdf

Morceiro, P. C. (2012). *Desindustrialização na economia brasileira no período 2000-2011: abordagens e indicadores.* São Paulo: Cultura Acadêmica. https://www.researchgate.net/publication/235333603_Desindustrializacao_na_economia_brasileira_no_periodo_2000-2011_abordagens_e_indicadores

Morceiro, P. C. (2018). *A indústria brasileira no limiar do século xxi: uma análise da sua evolução estrutural, comercial e tecnológica* (Doctoral dissertation, Faculdade de Economia, Administração e Contabilidade, Universidade de São Paulo, São Paulo). https://doi.org/10.11606/T.12.2019.tde-07122018-115824

Morceiro, P. C. (2021). Influência metodológica na desindustrialização brasileira. *Revista de Economia Política*, *41*, 700-722. https://doi.org/10.1590/0101-31572021-3195

Morceiro, P. C., & Guilhoto, J. J. (2023). Sectoral deindustrialization and long-run stagnation of Brazilian manufacturing. *Revista de Economia Política*, *43*, 418-441. https://doi.org/10.1590/0101-31572023-3340

Moreira, M. M. (1999). A indústria brasileira nos anos 90: o que já se pode dizer? In F. Giambiagi & M. M. Moreira (Eds.), *A economia brasileira nos anos 90.* Rio de

Janeiro: BNDES. http://web.bndes.gov.br/bib/jspui/handle/1408/11577

Morrone, H., Giovanini, A., & Berni, D. A. (2022). The brazilian deindustrialization thesis revisited: a subsystem approach 2000-2015. *Revista de Economia Contemporânea*, *26*, 1-24. https://doi.org/10.1590/198055272617

Muendler, M. A. (2004). *Trade, technology and productivity: A study of brazilian manufactures, 1986-1998* (Working Paper No. 148). Center for Economic Studies & Ifo Institute.

Nassif, A. (2008). Há evidências de desindustrialização no Brasil? *Revista de Economia Política*, *28*, 72-96. https://doi.org/10.1590/S0101-31572008000100004

Nassif, A., Bresser-Pereira, L. C., & Feijó, C. (2017). The case for reindustrialisation in developing countries: towards the connection between the macroeconomic regime and the industrial policy in Brazil. *Cambridge Journal of Economics*, *42*, 355-381. https://doi.org/10.1093/cje/bex028

Nordhaus, W. D. (2008). Baumol's diseases: A macroeconomic perspective. *Contributions in Macroeconomics*, *8*, 1382-1382. https://doi.org/10.2202/1935-1690.1382

Oreiro, J. L., & Feijó, C. A. (2010). Desindustrialização: conceituação, causas, efeitos e o caso brasileiro. *Revista de Economia Política*, *30*, 219-232. https://doi.org/10.1590/S0101-31572010000200003

Palma, J. G. (2005). Four sources of deindustrialization and a new concept of the dutch disease. In J. A. Ocampo (Ed.), *Beyond reforms: Structural dynamic and macroeconomic vulnerability.* Stanford, CA/Washington, DC: Stanford University Press/The World Bank. https://doi.org/10.1596/978-0-8213-5819-7

Radaelli, V., & Galetti, J. (2014). *Além da crise global: desafios de uma política industrial para a reindustrialização* (Radar No. 31). Brasília: Ipea. https://www.ipea.gov.br/portal/images/stories/PDFs/radar/140226_radar31_cap4.pdf

Ricupero, R. (2005). *Desindustrialização precoce: futuro ou presente do brasil? (síntese das principais teses e demonstrações do relatório trade and development report, 2003)* (Tech. Rep.). New York/Geneva: Unctad.

Rios, S. P., & Araujo Jr., J. T. (2013). Desempenho industrial e vantagens comparativas reveladas. In E. Bacha & M. de Bolle (Eds.), *O futuro da indústria no brasil: Desindustrialização em debate* (p. 227-247). Rio de Janeiro: Civilização Brasileira.

Rios, S. P., & Veiga, P. M. (2022). *Integrar para crescer: Uma proposta de liberalização comercial.* Rio de Janeiro: Centro de Estudos de Integração e Desenvolvimento. https://iepecdg.com.br/wp-content/uploads/2022/08/Apresentac%CC%A7a%CC%83o-Integrar-para-crescer-v6.pptx

Rodrik, D. (2016). Premature deindustrialization. *Journal of Economic Growth*, *2*, 1-33. https://doi.org/10.1007/s10887-015-9122-3

Schor, A. (2004). Heterogeneous productivity response to tariff reduction: Evidence from brazilian manufacturing firms. *Journal of Development Economics*, *75*, 373-

396. https://doi.org/10.1016/j.jdeveco.2004.06.003

Souza, K., & Silva, G. (2021). Taxa de câmbio real e produtividade da indústria brasileira no longo prazo: teoria, modelo. *Revista de Economia Política*, *41*, 657-678. https://doi.org/10.1590/0101-31572021-3158

Taylor, L. (1967). *Aggregate structural change: Recent time-series and cross-section evidence* (Doctoral dissertation). Harvard University.

Taylor, L. (1969). Development patterns: A simulation study. *The Quarterly Journal of Economics*, *83*, 220-241. https://doi.org/10.2307/1883081

Torres, R. L., & Cavalieri, H. (2015). Uma crítica aos indicadores usuais de desindustrialização no brasil. *Revista de Economia Política*, *35*, 859-877. https://doi.org/10.1590/0101-31572015v35n04a10

Veloso, F., Matos, S., Barbosa Filho, F. H., & Peruchetti, P. (2024). *Produtividade do trabalho no brasil: uma análise dos resultados setoriais no período 1995-2023*. Rio de Janeiro: Observatório de Produtividade Regis Bonelli IBRE/FGV. https://ibre.fgv.br/observatorio-produtividade/artigos/produtividade-do-trabalho-no-brasil-uma-analise-dos-resultados-1

Vergnhanini, R. (2013). O debate sobre a mudança estrutural da economia brasileira nos anos 2000. In *Anais do vi encontro internacional da associação keynesiana brasileira.* https://www.ie.ufrj.br/images/IE/PEPI/disserta%C3%A7%C3%B5es/2013/Rodrigo%20Vergnhanini.pdf

Özçelik, E., & Özmen, E. (2023). Premature deindustrialisation: The international evidence. *Cambridge Journal of Economics*, *47*, 725-746. https://doi.org/10.1093/cje/bead023

A Statistical Tests

In this appendix, we provide a series of statistical tests to assess the validity of our regressions. The first four figures present the Autocorrelation Functions (ACF) and Partial Autocorrelation Functions (PACF) of our autoregressive estimations [regressions (2) and (3)], examining individual residual autocorrelation in each of the first 20 lags. Table A1 presents the Ljung-Box test results with 10 lags to assess joint residual autocorrelation of regressions (2) and (3). Table A2 includes the Engle-Granger test to determine whether the regression residuals have a unit root, indicating non-stationarity in all regressions.

Figure A1: Autocorrelation Function - Regression (2) Residuals

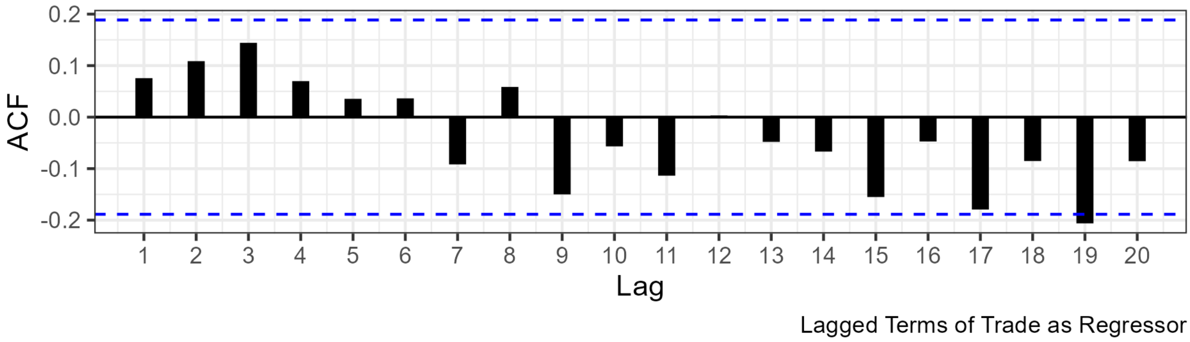


Figure A2: Partial Autocorrelation Function - Regression (2) Residuals

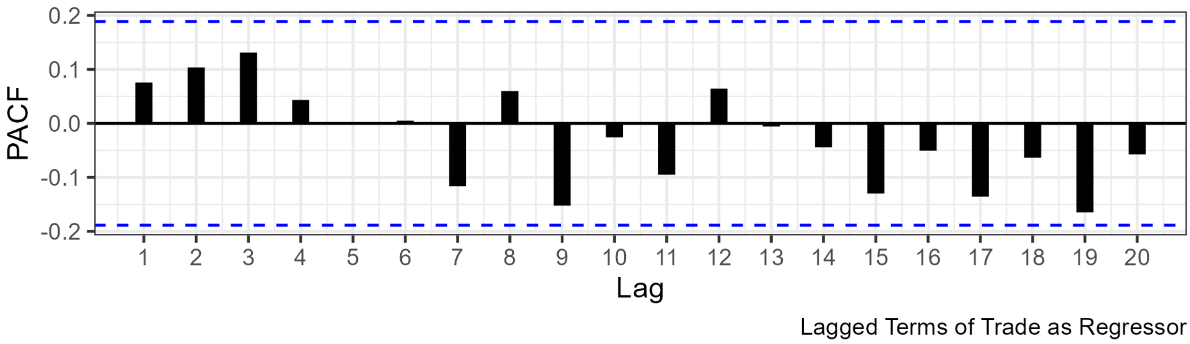


Figure A3: Autocorrelation Function - Regression (3) Residuals

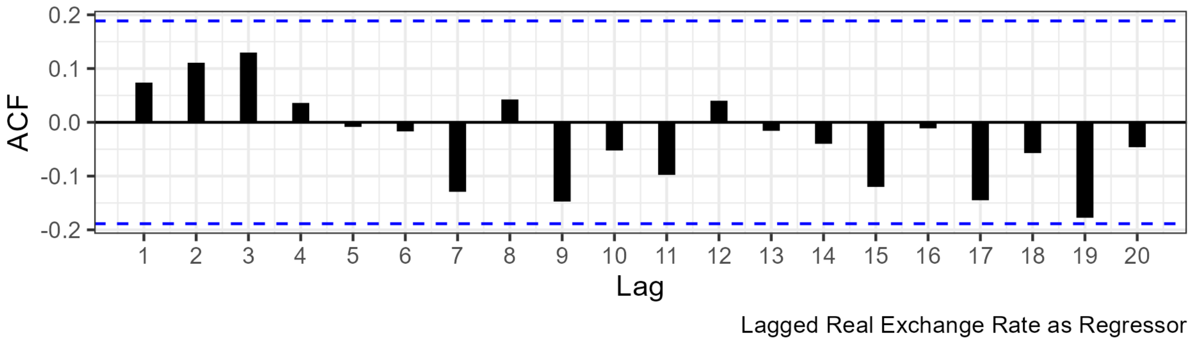
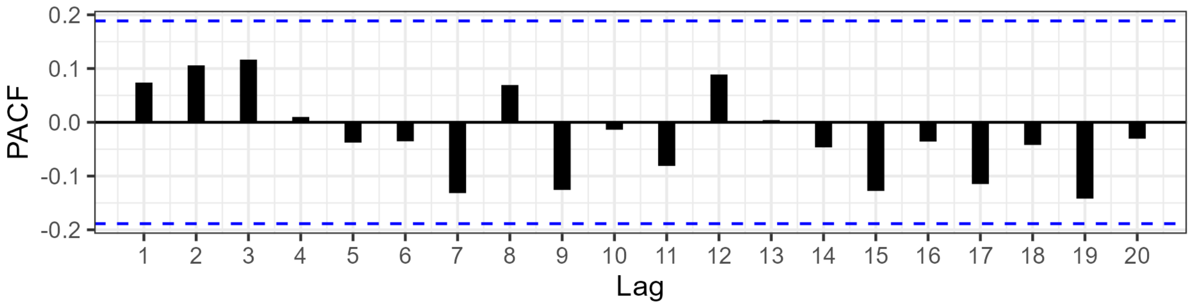


Figure A4: Partial Autocorrelation Function - Regression (3) Residuals



We clearly see that no lag of any regression exceeds the confidence interval bounds of the zero value in the ACF or PACF. Therefore, individual autocorrelation must not be present in the first 20 lags.

Table A1: Ljung-Box tests

	Brazilian Industrialization Rate - Constant Prices	
	(2)	(3)
Test Statistic	9.661	9.195
	(0.290)	(0.326)

P-values under coefficients.

The first column presents results for regression (2), which uses the Terms of Trade as a regressor, and the second column presents results for regression (3), which uses the Real Exchange Rate as a regressor. The p-values for the Ljung-Box tests are greater than 5%, so we can't reject the null hypothesis of no joint residual autocorrelation for 10 lags.

Table A2: Engle-Granger tests

	RER	Brazilian Industrialization Rate - Constant Prices	
	(1)	(2)	(3)
Test Statistic	-3.085	-6.259	-6.217
	(0.003)	(<0.001)	(<0.001)
Critical Value at 1%	-2.58	-2.58	-2.58
Critical Value at 5%	-1.95	-1.95	-1.95
Critical Value at 10%	-1.62	-1.62	-1.62
Observations	112	108	108

P-values under coefficients.

The first column presents results for regression (1), the first stage regression of the Real Exchange Rate. The second column presents results for regression (2), which uses the Terms of Trade as a regressor, and the third column presents results for regression (3), which uses the Real Exchange Rate as a regressor. All test statistics are smaller than their respective critical values at the 1% significance level. Therefore, we reject the null hypotheses of integrated residuals and conclude that the variables have a non-integrated linear combination, indicating that they are cointegrated.