

Structural transformation and labor productivity in Brazil*

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Keywords

multisector model, structural transformation, labor productivity

JEL Codes

O11, O14, O4

Abstract • Resumo

This paper examines the labor reallocation across agriculture, manufacturing, and services, and their impacts on aggregate labor productivity in Brazil from 1950 to 2010. We use a multisector model that features nonhomothetic preferences with constant elasticity of substitution and wedge distortions. This framework allows us to decompose the drivers of labor reallocation into supply-side, demand-side, and wedges. For the 1950–2010 period, demand-side effects were responsible for most of the reallocation of labor away from agriculture towards manufacturing and services. On the other hand, if we focus only on the 1980–2010 sub-period, supply-side drivers become the major determinant for labor reallocation.

1. Introduction

The Brazilian economy has undergone substantial transformations in the last six decades. Labor has reallocated away from agriculture and towards manufacturing and services. In this paper, we account for the sources of structural transformation in Brazil using a multisector model that features nonhomothetic preferences with constant elasticity of substitution. The model has three sources of labor reallocation.

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The supply-side driver is given by unequal productivity growth across sectors. The demand-side driver consists of changes in consumption patterns as income grows. Finally, the model also features distortions, captured as labor market wedges. The primary source of reallocation depends on the period analyzed. During the booming years, we observe that the income growth accounts for most of the reallocation; that is, the demand driver was stronger. On the other hand, during the years of recession and stagnation, the unequal productivity growth accounts for most of it; in other words, supply-side forces were stronger.

Due to the disparity in economic performance, the natural approach to study the Brazilian economy in the past 60 years is to analyze its performance in two sub-periods, 1950–1980 and 1980–2010. While during the first sub-period, the Brazilian economy was booming, during the second, it could barely keep the gains from the previous years. From 1950 to 1980, Brazil was a fast-growing economy with labor productivity increasing by more than 3-fold. Brazil seemed to be in the process of catching up with the most developed economies. In particular, its output per worker relative to that of the U.S. raised from 19.1% to 27.3%. However, in the second sub-period, Brazil experienced a recession followed by a slow growth phase. As a result, GDP growth rates plummeted, and the labor productivity gap with the U.S. increased. During this sub-period, the economy was falling behind the U.S. and, by 2010, Brazilian output per worker was equivalent to 20.4% of the American one.

The 1950–2010 period is also characterized by the persistent decline of the share of labor in agriculture and the persistent increase in services. In 1950, approximately two out of every three Brazilian workers worked in the agriculture sector. By 2010, the labor share in agriculture had decreased to 17%. In the same period, the share of services increased from 18.9% to 62.5%. The labor share in manufacturing increased from 16.3% up to 23.0% in the first sub-period and decreased to 20.5% by 2010. While the catching-up phase coincides with the increase in manufacturing labor share, the falling behind phase coincides with its decrease. This association between the economy's performance and manufacturing is constantly in academic and public discussions about the Brazilian economy. A recurring issue is what public policies could do to reverse this decline of manufacturing labor share. The appropriate answer depends on what is driving this process.

We use a standard structural transformation model with three sectors—agriculture, manufacturing, and services—and assume household preferences are nonhomothetic. Nonhomotheticity implies that changes in income will lead to changes in expenditure shares even if relative prices are constant.¹ Household preferences are represented by the implicit nonhomothetic constant elasticity of substitution (CES) utility function introduced in the structural transformation literature by [Comin, Lashkari, and Mestieri \(2021\)](#). This utility function is particularly

¹An example of nonhomothetic behavior is the empirical fact that the richer the households are, the smaller is their expenditure share with agricultural goods, despite the decline of its relative price.

suitable in the context of this paper because it generates nonhomothetic demand for every level of income. Moreover, given the significant increase of income in the Brazilian economy throughout the period, the constant income elasticity property helps match the model to the data.² In addition, the implicit nonhomothetic CES has the property that the elasticity of substitution between the consumption goods does not depend on their income elasticities, a property unique to this utility function.³

Our estimation results are in line with the literature on structural transformation. We find that the representative household has a preference for balanced consumption; that is, the goods of different sectors are complements. Complementarity implies that labor reallocates towards the sector with slow-growing productivity to compensate for the increasing difference in productivity and to produce enough goods to satisfy demand, characterizing the supply-side mechanism.⁴ We also find that manufacturing has a higher income elasticity of demand than agriculture and a lower income elasticity than services. Thus, following an increase in income, consumption of services increases more than consumption of manufacturing, and both services and manufacturing consumption increase more than agricultural consumption. As a result, labor moves towards income elastic sectors as income grows to meet demand, characterizing the demand-side mechanism.

The simulated economy successfully replicates the labor dynamics and the aggregate labor productivity for the entire 1950–2010 period. In particular, it reproduces the hump-shaped labor share of manufacturing and the behavior of the labor share in agriculture and services. Moreover, the simulated economy mimics the data displaying the two marked sub-periods: the first one in which aggregate productivity exhibits strong growth and the second in which it stagnates.

To decompose the sources of labor reallocation, we apply the insights of the accounting methodology of [Chari, Kehoe, and McGrattan \(2007\)](#) to our benchmark structural transformation model. This methodology allows us to compute wedges as distortions in the labor demand that capture differences between model and data. These distortions are such that the model with wedges reproduces the labor shares in Brazil exactly. Then, we use the model to quantify how much of the variation in labor shares can be accounted for by the demand-side driver (income growth), supply-side driver (unequal sectoral productivity growth), and distortions in the economy. We find that during the first sub-period, the demand-side driver is

²This utility function contrasts with the commonly used generalized Stone–Geary class of utility functions ([Kongsamut, Rebelo, & Xie, 2001](#); [Dennis & Işcan, 2009](#); and [Herrendorf, Rogerson, & Valentinyi, 2013](#)) that generates nonhomothetic effects by imposing subsistence (or endowment) levels. These exogenous subsistence levels cause significant nonhomothetic effects for low income levels, but these effects vanish as income grows. As a consequence, these preferences are asymptotically homothetic.

³Among those used in the structural transformation literature, to the best of our knowledge.

⁴See [Ngai and Pissarides \(2007\)](#) for a structural transformation framework with labor reallocation entirely driven by sector-specific productivity growth.

responsible for basically all the reallocation of labor. During the second sub-period, the supply-side mechanism becomes the primary driver of structural transformation. For both sub-periods, the sectoral wedges had only a small impact.

Finally, we perform two counterfactual exercises by varying sectoral labor productivity. First, we ask how the Brazilian economy would have behaved if manufacturing productivity had grown at the U.S. average growth rate to evaluate the importance of the labor productivity of the manufacturing sector. Between 1950 and 1980, manufacturing labor productivity in Brazil grew faster than in the U.S. and, also, than in the agriculture and services sectors. Between 1980 and 2010, however, manufacturing productivity grew only slightly. As a result, we find that aggregate productivity would be 14.3% lower than observed in 1980 and about the same level in 2010. In the second counterfactual, we ask how the Brazilian economy would have behaved if services productivity was constant at its 1980 level to evaluate the striking fact that, from 1980 to 2010, services productivity declined to a level close to the observed in 1950. We find that aggregate productivity in 2010 would be 27.6% higher than in the data.

This paper closely relates to a vast structural transformation literature that goes back to [Kuznets \(1957\)](#), [Baumol \(1967\)](#), and [Maddison \(1980\)](#). More recently, most of the papers consider supply and demand drivers of structural transformation in their frameworks such as [Dennis and Işcan \(2009\)](#), [Buera and Kaboski \(2009\)](#), and [Herrendorf, Rogerson, and Valentinyi \(2014\)](#), just to cite a few. In particular, our paper combines the sectoral production structure used by [Duarte and Restuccia \(2010\)](#) with the nonhomothetic CES utility function used by [Comin et al. \(2021\)](#). This work also closely relates to the studies that apply a wedge accounting methodology in the context of structural transformation, such as [Cheremukhin, Golosov, Guriev, and Tsyvinski \(2016\)](#), [Cheremukhin, Golosov, Guriev, and Tsyvinski \(2015\)](#), and [Świącki \(2017\)](#).

The subset of this literature that specifically studies structural transformation in Brazil is especially relevant for our paper. [Firpo and Pieri \(2017\)](#) find that labor reallocation was the main force behind the economic growth between 1950 and 1970 in the Brazilian economy. After this period, the authors find that most of the increase in productivity came from the within-sector component. [Santos and Spolador \(2018\)](#) study the Brazilian economy starting in 1981 in the context of a model with capital whose structural transformation process is entirely supply-side driven. [Cai \(2015\)](#) quantifies the role of labor market distortions in four countries (Brazil, India, Mexico, and the U.S.) and finds that Brazil has the largest frictions in all sectors. However, he concludes that improving labor market efficiency contributes little to the reallocation of labor. Finally, the work of [Ferreira and Silva \(2015\)](#) that studies the process of structural transformation for a group of Latin American countries, including Brazil, is the paper most closely related to ours. They find that services labor productivity explains a sizable portion of the economy's stagnation of the later

decades. Our second counterfactual exercise points in the same direction. The main difference between our paper and Ferreira and da Silva's is that we extend the analysis to account for the exact sources of labor reallocation.

The rest of the paper is organized as follows. [Section 2](#) contains the main stylized facts on growth and structural transformation in Brazil. [Section 3](#) develops the model and explains its main properties and the parameters selection. [Section 4](#) presents and discusses the results for our benchmark economy. [Section 5](#) measures the distortions in the Brazilian economy and [Section 6](#) performs the decomposition exercise. [Section 7](#) analyzes the importance of each sector's labor productivity to overall aggregate productivity by means of counterfactual exercises. [Section 8](#) concludes.

2. Data and facts

In this section, we document the stylized facts of the structural transformation process in Brazil from 1950 to 2010. We use the Groningen Growth and Development Centre 10-Sector Database for sectoral value added in constant prices of 2005 and employment data.⁵ This database defines each sector of economic activity according to the international standard industrial classification of economic activities of the United Nations (ISIC 3). Using these data, we construct production and labor input series for our three broad sectors—agriculture, manufacturing, and services.⁶ We then incorporate population data from the Penn World Tables version 9.0 (PWT), and real GDP per capita from the [The Maddison-Project \(2013\)](#)⁷ into our time series dataset. Since our analysis focuses on the long-run behavior of the economy, all data have been filtered using the Hodrick-Prescott filter with a smoothing parameter equal to 100.

⁵The Groningen Growth and Development Centre 10-Sector Database provides value added in constant prices from 1950 to 2011 and in current prices from 1990 to 2011. The Brazilian national statistical agency Brazilian Institute of Geography and Statistics (*Instituto Brasileiro de Geografia e Estatística*) only provides economic series at sectoral level starting from 1970 on. Because of the large economic growth observed during the 1950–1970 period and of the industrialization policies of the period, we decided to use the longer series despite its limitations.

⁶Agriculture corresponds to ISIC code AtB (agriculture, forestry, hunting, and fishing), manufacturing to C-F (mining and quarrying, manufacturing, construction and, electricity, gas, and water supply), and services correspond to all the other sectors.

⁷The real GDP per capita is in 1990 Geary–Khamis international dollars. See [Bolt and van Zanden \(2014\)](#).

2.1 An overview of the Brazilian economy

From 1950 to 1980, Brazil experienced a fast-paced labor productivity growth, measured as output per worker.⁸ In 1950, output per worker was \$ 5,704 (in 2005 local prices), and in 1980 it had more than tripled to \$ 19,216. Then, from 1980 to 2010, the Brazilian economy was characterized by a decade-long recession⁹ where output per worker declined through the mid-1990s and a slow recovery afterward. As a result, output per worker in 2010 was \$19,931, only slightly higher than in 1980. Figure 1(a) plots output per worker for 1950–2010 in 2005 local prices. The graph illustrates the fast growth pre-1980s and the stagnation post-1980. In particular, aggregate labor productivity only reached its maximum 1980s level again in 2008. The Brazilian output per worker grew at a 4.04% annual rate on average in the first sub-period and a modicum 0.16% rate post-1980 (see Table 1).

The rapid increase of aggregate productivity growth from 1950 to 1980 narrowed the gap between the Brazilian and the American productivities, as displayed in Figure 1(b). In 1950, the Brazilian GDP per worker was equivalent to 19.1% of that in the United States. By 1980, this ratio increased 1.4-fold, and the Brazilian GDP per worker was 27.3% of the American one. In the following years, however, the

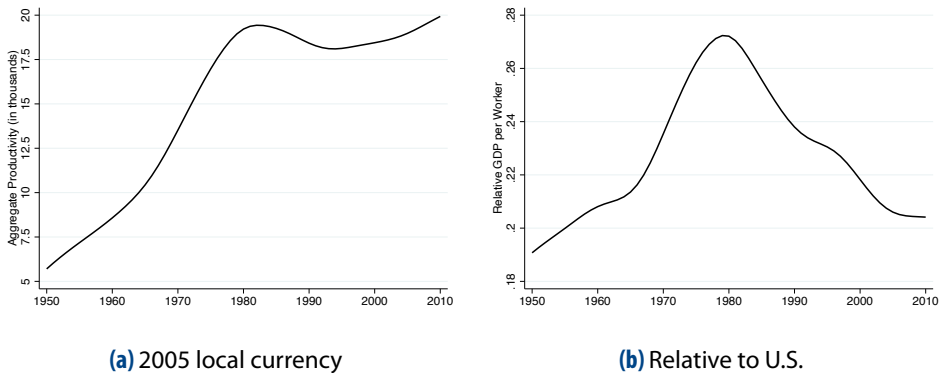


Figure 1. BRAZILIAN GDP PER WORKER

Panel (a) displays the value added per worker (2005 local currency, in thousands). Panel (b) displays the value added per worker in Brazil relative to the U.S.

⁸Following the literature on structural transformation in Brazil, such as [Ferreira and Silva \(2015\)](#), we adopt output per worker as our productivity measure due to the unavailability of data on hours worked by sector.

⁹Brazil experienced a depression, as defined by [Kehoe and Prescott \(2002\)](#); that is, a large and persistent deviation of aggregate output per working-age person from its trend, such that it falls at least 15% within the first decade and remains at least 20% below trend. For more on the Brazilian depression of the 1980s, see [Bugarin, Ellery, Gomes, and Teixeira \(2007\)](#).

Table 1. OUTPUT PER WORKER IN BRAZIL

This table shows the first and last year levels and growth rate per period. Output per worker and employment data were calculated using Groningen 10 sector database.

Period	first and last years levels (2005 local prices)	annual growth rate (period average)
1950–1980	5,704–19,216	4.04%
1980–2010	19,216–19,931	0.16%
1950–2010	5,704–19,931	2.08%

Brazilian economy lost some of the gains conquered in the first sub-period and had its relative GDP per worker reduced to 20.4% by 2010.

The behavior of the Brazilian economy throughout these 60 years follows a pattern familiar to most Latin American countries. In the first phase, these economies were taking off into growth and benefiting from worldwide trends such as a more urban population, lower dependence on agriculture, and increased educational attainment levels. However, in a second phase, these economies fell behind and were unable to keep catching up with the U.S. economy (Costa, Kehoe, & Raveendranathan, 2016).

2.2 Structural transformation

The reallocation of economic activity across sectors that accompanies economic growth characterizes the process of structural transformation. A standard measure of economic activity at the sectoral level is the employment share. The stylized facts of structural transformation are a decline in agriculture employment share, a hump shape in manufacturing and an increase in services through time. At initial development stages, labor reallocates from agriculture towards manufacturing and services. And, as the economy develops, from agriculture and manufacturing towards services.¹⁰ Figure 2 exhibits the evolution of the labor reallocation process in Brazil.

In 1950, 64.8% of the Brazilian labor force worked in the agriculture sector, 16.3% in the manufacturing sector, and the remaining 18.9% in the services sector. The share of employment in manufacturing reached its peak of 23.0% in 1983, and then it started to decline, granting its characteristic hump-shaped pattern. Notice that, in 1983, the employment share in services was already above that of agriculture, 44.2% and 32.8%, respectively. In the last year of our data series, 2010, Brazil had 17% of its labor force in agriculture, 20.5% in manufacturing, and 62.5% in services.

Although Brazil presents the main characteristics of structural transformation processes common to many other countries, it has particularities. Herrendorf et

¹⁰For a further discussion on the stylized facts, see Maddison (1980) and Herrendorf et al. (2014).

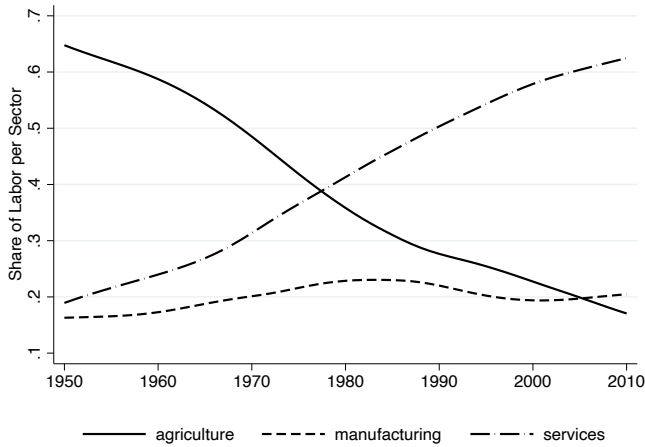


Figure 2. Share of employment by sector in Brazil

al. (2014) document that the employment share in manufacturing peaks at a GDP per capita of around \$8,100 (1,990 international dollars¹¹) for both rich and poor countries, a level that Brazil has yet to achieve. As a comparison, Table 2 shows the characteristics of Brazil and the United States in the year that each country reached their manufacturing employment share peak.

Figure 3 shows labor productivity level by sector. Until the mid-1980s, labor in the services sector was the most productive of the economy. Manufacturing labor productivity caught up with services’ productivity in 1987, four years after the peak of manufacturing employment share. Note that this change is primarily due to the falling services labor productivity rather than an improving performance of manufacturing productivity. In fact, in 1987, manufacturing productivity was declining when it first became more productive than services. And after a good

Table 2. Manufacturing employment share peak

Summary statistic	Brazil	United States
Peak year	1983	1950
GDP per capita (Int’l \$)	4,908	9,809
Manufacturing employment share	23.0%	33.4%

Note: The American manufacturing employment share peaks in the first year of our sample and decreases in all years of the analysis.

¹¹Also known as Geary–Kahmis dollar, which reflects the current year’s exchange rate with current PPP adjustments.

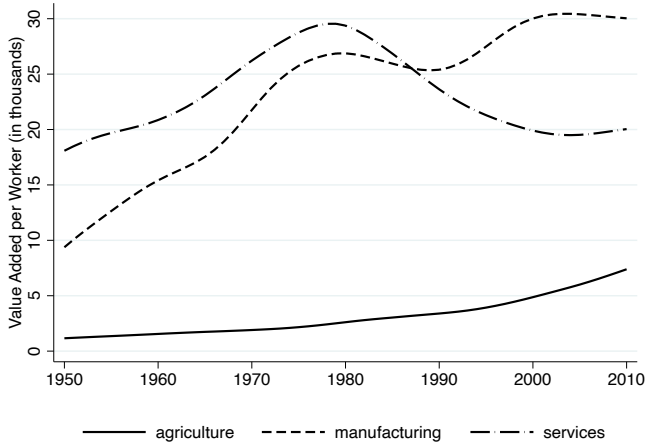
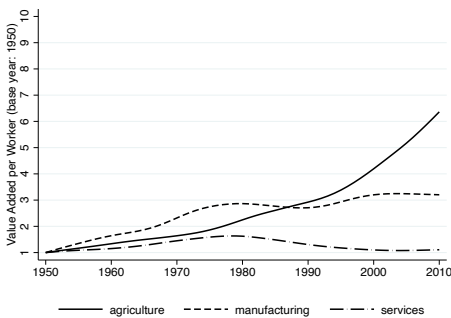


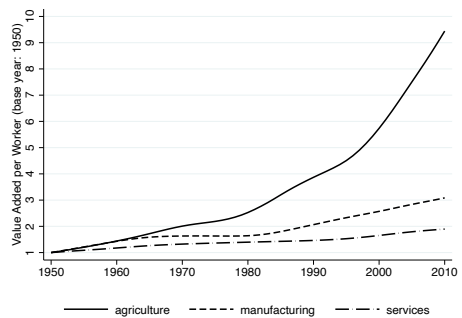
Figure 3. Labor productivity by sector

performance in the 1990s, manufacturing productivity was mostly constant during the 2000s.

Figure 4 compares labor productivity growth by sector for Brazil and the U.S. Agriculture was the fastest growing sector in both countries, with manufacturing following in second and services having the slowest growth. This pattern is also observed in most countries.¹² Labor productivity in agriculture grew 6.3 times in Brazil and 9.4 times in the U.S. from 1950 to 2010. Manufacturing labor productivity grew about the same in both countries from 1950 to 2010, 3.2 times in Brazil and 3.1 in the U.S. Although manufacturing stagnated for most of the 1960s and the 1970s,



(a) Brazil



(b) U.S.

Figure 4. Normalized Sectoral Productivity – Brazil and U.S.

¹²See Duarte and Restuccia (2010) and Herrendorf et al. (2014).

it grew at a fast pace for the remaining of the period. Meanwhile, manufacturing in Brazil grew steadily until the 1980s, displayed a stagnation period, briefly recovered after the liberalizing economic reforms of the early 1990s, and finally entered a new stagnation phase. For the 1950–1980 period, Brazilian manufacturing productivity actually grew faster than in agriculture. Services is the sector that had the most diverging behavior in terms of labor productivity for the two countries. While services productivity in the U.S. grew steadily throughout the period, it displayed a more erratic behavior in Brazil. Services labor productivity in Brazil peaked in 1979,¹³ after growing by 1.6-fold, but then declined steadily and ended the analyzed period at roughly the same level as in 1950. Table 3 reports the average productivity growth rates observed in Brazil and the U.S. during the sub-periods.

Jointly analyzing figures 2 and 3, it is possible to explain the movements of aggregate productivity depicted in Figure 1. Because aggregate labor productivity is the sum of labor productivity across sectors weighted by the share of employment in each sector, reallocation of labor affects aggregate productivity. As the agricultural productivity increased, more and more of the labor force in that sector was reallocated towards the other two sectors. While the manufacturing sector was absorbing some of these workers, the overall Brazilian productivity grew quickly as productivity in the manufacturing sector was larger than in agriculture both in terms of level and growth rate. The deceleration of manufacturing productivity growth coincides with the peak of its labor share. At this time, the services sector was absorbing labor from both agriculture and manufacturing. However, services productivity was declining and, together with the sluggish behavior of manufacturing productivity, total productivity in the Brazilian economy declined.

Table 3. AVERAGE PRODUCTIVITY GROWTH RATES

This table shows the average percentage growth rates of labor productivity in agriculture (Agric), manufacturing (Manuf), and services (Serv) for Brazil and U.S. for three different periods. The catching up period of 1950–1980 is characterized by the fast growth in manufacturing labor productivity. The stagnation period of 1980–2010 is characterized by the slow growth of manufacturing productivity and the decline in services productivity.

	Brazil			United States		
	Agric	Manuf	Serv	Agric	Manuf	Serv
1950–2010	3.08	1.95	0.18	3.76	1.87	1.06
1950–1980	2.65	3.47	1.58	3.04	1.63	1.09
1980–2010	3.55	0.37	-1.24	4.48	2.07	1.01

¹³The peak in the data before using the HP filter actually happened in 1980.

3. Model

This section presents the model that guides our analysis of the sectoral reallocations of labor and aggregate labor productivity in the Brazilian economy. We build on the structural transformation literature that uses both demand and supply drivers of labor reallocation. On the supply side, our model closely follows Duarte and Restuccia (2010) in the use of sector-specific productivity growth that generates different price paths across sectors. On the demand side, we assume a representative household has preferences represented by the implicit nonhomothetic CES utility function, introduced in the structural transformation literature by Comin et al. (2021). This utility function is particularly suitable in the context of this paper because it generates nonhomothetic demand for every level of income. In addition, the implicit nonhomothetic CES has the property that substitution and income elasticities are independent of each other, allowing us to identify each elasticity separately.

Our model economy has three sectors: agriculture (a), manufacturing (m) and services (s). The representative firm of each sector uses labor as the sole input of production, and the production function is assumed to be linear in labor. The representative household consumes agricultural, manufacturing, and services goods and supplies labor inelastically. Because there is no capital in the economy, all the output produced is consumed, and the model is a sequence of static problems.

3.1 Firms

The representative firm of sector $i \in \{a, m, s\}$ produces according to the following linear production function

$$Y_i = A_i L_i, \quad (1)$$

where Y_i is output, L_i is labor input, and A_i is a sector-specific productivity. The labor input, L_i , is defined as total employment in sector i .

The representative firm of each sector behaves competitively in markets for both goods and labor. In each period, firm i takes price p_i and wage w as given to solve its static profit maximization problem:

$$\max_{L_i > 0} \{p_i A_i L_i - w L_i\}. \quad (2)$$

3.2 Households

The representative household is endowed with L units of time each period which are supplied inelastically in the labor market. Her period preferences over consumption are represented by the utility function

$$U(C) = \ln(C), \quad (3)$$

where C is the aggregate consumption index. The aggregate consumption combines sectoral goods, c_i for $i \in \{a, m, s\}$, according to the implicit nonhomothetic CES aggregator as in [Comin et al. \(2021\)](#):

$$\sum_i \Omega_i^{1/\sigma} C^{(\epsilon_i - \sigma)/\sigma} c_i^{(\sigma - 1)/\sigma} = 1, \tag{4}$$

where $\sigma \in (0, 1)$ is the elasticity of substitution; $\Omega_i > 0$ is a constant weight for each sector $i \in \{a, m, s\}$; and ϵ_i is a measure of the income elasticity of demand for good i .¹⁴ The standard CES aggregator is the special case of equation (4) when $\epsilon_i = 1$ for all i . When $\epsilon_i \neq 1$, for at least one i , this parameter drives the weight of consumption of good i as aggregate consumption C increases. Even though there is no closed-form solution for aggregate consumption as a function of the sectoral consumption goods, the demand functions are still tractable.

The budget constraint of household is given by:

$$p_a c_a + p_m c_m + p_s c_s = wL. \tag{5}$$

Given prices, the representative household chooses consumption of each good c_i to maximize the period-by-period utility subject to a budget constraint and standard non-negativity constraints.

3.3 Market clearing

The demand for labor from firms equal the exogenous supply L :

$$L = L_a + L_m + L_s. \tag{6}$$

And, at each date, the market for goods clear:

$$c_i = Y_i, \quad \forall i \in \{a, m, s\}. \tag{7}$$

3.4 Equilibrium

A competitive equilibrium is a set of prices $\{p_a, p_m, p_s, w\}$, allocations $\{c_a, c_m, c_s\}$ for the household, and allocations $\{L_a, L_m, L_s\}$ for the firms such that: (i) given prices, household's allocations solve her utility maximization problem; (ii) given prices, firms' allocations solve the profit maximization problem; (iii) labor and goods markets clear.

¹⁴We will refer to ϵ_i as income elasticity parameter. Notice that ϵ_i is not equal to the income elasticity of demand for good i . The income elasticity is:

$$\eta_i = \frac{\partial \ln(c_i)}{\partial \ln(E)} = \sigma + (\epsilon_i - \sigma) \frac{(1 - \sigma)}{\bar{\epsilon} - \sigma},$$

where E corresponds to expenditure; $\bar{\epsilon} = \sum_i \omega_i \epsilon_i$; and ω_i is the share of income spent on good i .

To characterize the competitive equilibrium, we first normalize wages to one. Then firm's optimal choice implies that the price in each sector $i \in \{a, m, s\}$ is the inverse of the sector productivity:

$$p_i = \frac{1}{A_i}. \quad (8)$$

As a consequence, more productive sectors have lower prices. For any two sectors $i, j \in \{a, m, s\}$, their relative price is given by the ratio of their productivities, $p_i/p_j = A_j/A_i$.

Now, we turn to the household choice. Household demand for good i is given by

$$c_i = \Omega_i \left(\frac{p_i}{P} \right)^{-\sigma} C^{\epsilon_i}, \quad (9)$$

where P is the aggregate price index:

$$P \equiv \frac{\sum_i p_i c_i}{C} = \frac{1}{C} \left[\sum_i \Omega_i C^{\epsilon_i - \sigma} p_i^{1-\sigma} \right]^{\frac{1}{1-\sigma}}. \quad (10)$$

Define expenditure share on good i as $\omega_i = (p_i c_i)/(PC)$. Using household demand from equation (9), expenditure share may be rewritten as

$$\omega_i = \Omega_i \left(\frac{p_i}{P} \right)^{1-\sigma} C^{\epsilon_i - 1}. \quad (11)$$

From the definition of expenditure share and equation (8), it is easy to see that $L_i = \omega_i PC$. From household budget constraint and equation (10), we have that $PC = L$. So, we find that the labor share in sector i is equal to the expenditure share

$$\omega_i = \frac{L_i}{L}. \quad (12)$$

Intuitively, as the expenditure share on good i increases, labor allocated for sector i production also increases to meet demand. Using the fact that the sum of expenditure shares equals one, we may characterize labor share as a function of productivities and aggregate consumption:

$$\frac{L_i}{L} = \frac{\Omega_i C^{\epsilon_i} A_i^{\sigma-1}}{\sum_i \Omega_i C^{\epsilon_i} A_i^{\sigma-1}}. \quad (13)$$

From equation (9), relative consumption can be written as a function of relative prices and aggregate consumption:

$$\frac{c_i}{c_j} = \frac{\Omega_i}{\Omega_j} \left(\frac{p_i}{p_j} \right)^{-\sigma} C^{\epsilon_i - \epsilon_j}. \quad (14)$$

From this equation, we can see two properties of the nonhomothetic CES utility function. First, the elasticity of relative demand with respect to consumption index is constant and heterogeneous across sectors:

$$\frac{\partial \ln(c_i/c_j)}{\partial \ln(C)} = \epsilon_i - \epsilon_j. \tag{15}$$

This property ensures that the nonhomotheticity does not vary as income grows; that is, the degree of nonhomotheticity is the same for all levels of income. Second, the elasticity of substitution between goods is constant:

$$\frac{\partial \ln(c_i/c_j)}{\partial \ln(p_i/p_j)} = -\sigma. \tag{16}$$

Notice that this functional form delivers a perfect separation of the supply and the demand effects. While the price effect always generates a negative correlation between relative real sectoral consumption and relative sectoral prices, the demand effect makes both aggregates co-move in aggregate consumption.

3.5 Parameter selection

Notice that the real consumption index C is not directly observable and we write it in terms of variables that are measurable in the data. Let $E = PC$ be consumption expenditure. Equation (11) can be rewritten as

$$\omega_i = \Omega_i \left(\frac{p_i}{E} \right)^{1-\sigma} C^{\epsilon_i - \sigma}. \tag{17}$$

Because the optimal allocation depends solely on the difference between ϵ 's, in the rest of the paper we consider agriculture as the reference sector and we normalize its income elasticity parameter to one, $\epsilon_a = 1$. Using optimal condition (12), $\omega_a = L_a/L$, and $p_a = 1/A_a$, the consumption index C equals

$$C = A_a E \left(\frac{L_a/L}{\Omega_a} \right)^{\frac{1}{1-\sigma}}, \tag{18}$$

where all terms of right hand side of equation (18) are observable in the data. To compute C we consider E equal the GDP per capita since there are no savings in the model. We normalize sectoral labor productivity to one in 1950, $A_{i,1950} = 1$. Then, we set Ω_a equal to the share of labor in agriculture in the initial period, $\Omega_a = L_{a,1950}/L_{1950}$, so that $C = 1$ in 1950. Notice, however, that C depends on the parameter σ , a parameter we still need to pin down.¹⁵

¹⁵In Figure 12 (at page 493), we compare our measure of consumption index C with the GDP per capita behavior.

Now we turn to the calibration of the sectoral preference weight, $\Omega_i, i \in \{m, s\}$. The preference weighting Ω_i is calculated so that the labor share of the sectors in the model matches the data in 1950. Given the normalizations of the labor productivity A_i and consumption index C , we use equation (13) to determine Ω_i as

$$\Omega_i = \frac{L_{i,1950}}{L_{1950}}. \tag{19}$$

That is, the preference weighting equals the labor share in 1950.

The estimation of preference parameters is based on the relative allocation of labor $L_i/L_a, i \in \{m, s\}$. To do so, we use relative expenditure ω_i/ω_a determined from equation (17), and equation (12), $\omega_i = L_i/L$, together with the condition that relative prices equal the inverse of relative productivity $p_i/p_a = A_a/A_i$. Substituting the real consumption index C determined in equation (18), the natural logarithm of the relative labor can be written in terms of observables as

$$\ln\left(\frac{L_i}{L_a}\right) = \ln\left(\frac{\Omega_i}{\Omega_a}\right) + (1 - \sigma)\ln\left(\frac{A_a}{A_i}\right) + (\epsilon_i - 1)\ln(A_a E) + \frac{\epsilon_i - 1}{1 - \sigma}\ln\left(\frac{L_a}{L}\right) - \frac{\epsilon_i - 1}{1 - \sigma}\ln(\Omega_a). \tag{20}$$

To identify the parameter values $(\sigma, \epsilon_m, \epsilon_s)$, we target the shares of labor in manufacturing and in services for the whole period. We choose the parameter values that minimize the sum of the squared difference between the share of labor implied by the model and the observed in the data.

Our estimate of the elasticity of substitution, σ , is 0.2495. The difference in income elasticity parameters between agriculture and manufacturing, $\epsilon_m - \epsilon_a$ is positive and equal to 0.7502. The difference in income elasticities between services and agriculture, $\epsilon_s - \epsilon_a$ is positive and equal to 0.8021. Those numbers imply that manufacturing is more income elastic than agriculture and that services is more income elastic than manufacturing, as expected.

As in [Comin et al. \(2021\)](#), we also find that the elasticity of substitution, σ , is statistically different from zero. This result contrasts with previous estimations that have commonly relied on Stone–Geary utility functions.¹⁶ Because in the Stone–Geary utility function the demand effect becomes less important as consumption

¹⁶The generalized Stone–Geary utility has the functional form

$$u(c_a, c_m, c_s) = \log(C)$$

such that

$$C = \left[\sum_i \Omega_i^{1/\sigma} (c_i + \bar{c}_i)^{(\sigma-1)/\sigma} \right]^{\frac{\sigma}{\sigma-1}},$$

where $\bar{c}_a < 0, \bar{c}_m = 0$, and $\bar{c}_s > 0$.

grows, its estimated substitution parameter σ asymptotically goes to zero.¹⁷ This implies that the estimation based on Stone–Geary preferences relies more on the price effects and the complementarity of consumption. The usual example of the literature is the increase in the relative consumption of services while services relative price also increase. Due to the vanishing demand effects of the Stone–Geary preferences, increases in the relative consumption of services require that the goods have very low substitutability. In the limit, the elasticity parameter σ goes to zero. For example, Buera and Kaboski (2009), Herrendorf et al. (2013), and Moro, Moslehi, and Tanaka (2017) find that the substitution parameter σ is not statistically different from zero.¹⁸ For Brazil, Ferreira and Silva (2015) calibrate the elasticity parameter σ to be fairly inelastic, but different from zero though.

4. Results for the Benchmark Economy

To analyze the model’s fit to the data, we feed the model with the observed labor productivity paths A_i and the observed path of the aggregate consumption index C . Then, we evaluate how well the model captures the behavior of the labor shares and aggregate productivity.

Overall, our simulated economy successfully matches the data. The shares of employment implied by the benchmark model are reported in Figure 5(a) together with data. The model reproduces the fall in the share of labor in agriculture and

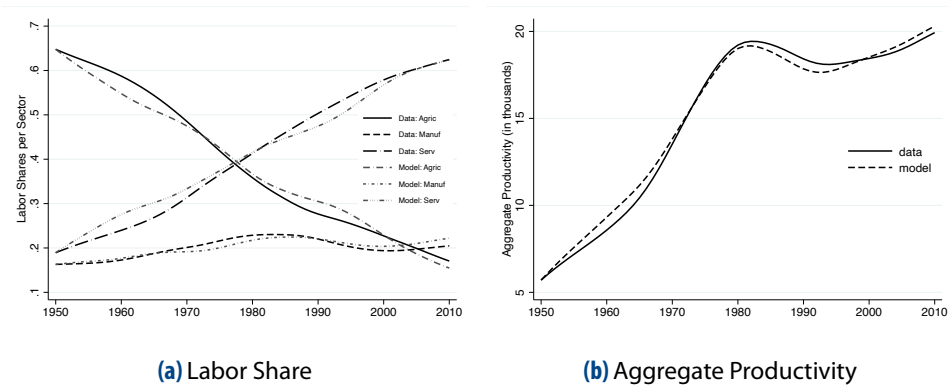


Figure 5. LABOR SHARE ALLOCATION AND AGGREGATE PRODUCTIVITY
 Panel (a) compares sectoral share of labor in the data and in the model. Panel (b) compares aggregate productivity in the data and in the model.

¹⁷Notice that the nonhomotheticity effects are generated by parameters \bar{c}_i and these effects decrease as consumption c_i increases.

¹⁸See Comin et al. (2021) for further discussion.

the persistent increase in services. Putting into numbers, the share in agriculture declines from 64% in 1950 to 17% in 2010 while it declines to 15% in the model. In services, the share of labor increases from 19% to 62%, and in the model, it also reaches 62%. Turning to the hump shape in manufacturing, the model generates an increase in the labor share from 17% to 22% in 1983, while in the data, it reaches 23%. Afterward, the model implies a decline until the early 1990s, followed by a small increase. As a summary statistic of the performance of the model, the average absolute deviation between the sectoral labor share in the model and in the data¹⁹ are 1.7% in agriculture, 0.7% in manufacturing and 1.6% in services.

In the model, aggregate productivity equals the average of sectoral labor productivities weighted by their labor shares:

$$\frac{Y}{L} = \sum_{i \in \{a, m, s\}} \frac{Y_i L_i}{L_i L}.$$

Therefore, the behavior of aggregate productivity depends on the behavior of sectoral productivities A_i and of the labor shares L_i/L through time. Because labor productivity is exogenous and the model is able to reproduce salient features of the labor allocation across sectors, the simulated economy closely reproduces the aggregate productivity. The results are plotted in Figure 5(b).

5. Wedges: Distortions in the Brazilian Economy

Even though our framework captures the long-run behavior of the sector labor shares, some discrepancies exist between the model and data. Following the methodology of Chari et al. (2007), we use the benchmark model²⁰ to compute sectoral wedges that account for the differences between model allocation and data. These wedges reflect distortions in the economy that are not captured by the benchmark model. Here they are represented by labor demand costs and are calculated such that, given the productivity and aggregate consumption paths, the model labor shares equal the data labor shares. Consider the modified problem of a firm in sector $i \in \{a, m, s\}$:

$$\max_{L_i > 0} \{p_i A_i L_i - (1 + \tau_i) w L_i\}, \quad (21)$$

where $(1 + \tau_i)$ represents the wedge on labor demand in sector i . In the presence of wedges, the equilibrium price is²¹

$$p_i = \frac{1 + \tau_i}{A_i}. \quad (22)$$

¹⁹We calculate the average absolute deviation between the sectoral share of labor in the model x_i^m and the data x_i^d as $(1/T) \sum_{t=1950}^{2010} \text{abs}(x_{i,t}^d - x_{i,t}^m)$, where $T = 61$ is the number of years.

²⁰We will call the model developed in section 3 as 'benchmark model' through the rest of the paper.

²¹As in the benchmark model, wage w is normalized to one.

Plugging the new price equation into the relative consumption equation (14), we find that

$$\frac{c_i}{c_j} = \frac{\Omega_i}{\Omega_j} \left(\frac{(1 + \tau_i) A_j}{(1 + \tau_j) A_i} \right)^{-\sigma} C^{\epsilon_i - \epsilon_j}. \tag{23}$$

The relative wedges of sector $i \in \{m, s\}$ to agriculture can be computed analytically:

$$\frac{1 + \tau_i}{1 + \tau_a} = \left[\frac{\Omega_i L_a}{\Omega_a L_i} \left(\frac{A_a}{A_i} \right)^{1-\sigma} C^{\epsilon_i - \epsilon_a} \right]^{\frac{1}{\sigma}}. \tag{24}$$

Using the data on employment shares, sectoral productivities and aggregate consumption, we compute the relative manufacturing and services wedges. We set the notation $1 + \tau_{ia} = (1 + \tau_i)/(1 + \tau_a)$. Figure 6 plots the results.

If wedge $1 + \tau_{ia} < 1$, $i \in \{m, s\}$, (relative) labor demand in sector i is as if the labor cost was lower than the market cost and the labor allocation is higher in the data than predicted by the model. For example, we observe in Figure 6 that, between 1970 and the late 1990s, $1 + \tau_{ma} < 1$ and, in Figure 5(a), that manufacturing labor share in the model is lower than in the data. We interpret a wedge less than one as a distortion/subsidy that incentivizes allocation towards sector i (relative to agriculture). On the other hand, if $1 + \tau_{ia} > 1$, labor demand is as if the labor cost was higher than the market cost. So, allocation is lower in the data than predicted by the model. Consider the wedges and labor shares for the services sector. The model predicts a higher labor allocation than observed in the data until the mid-1970s, and its wedge is positive during this period.

We do not take a stand on the specific frictions that explain the sources of the wedges. Possible explanations are incentives to capital goods production,

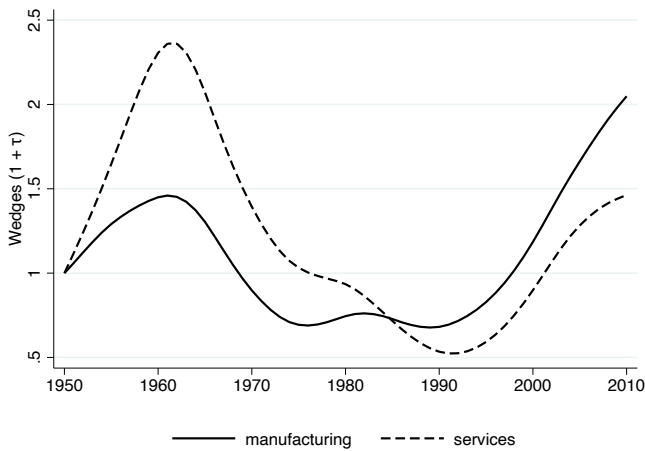


Figure 6. WEDGES

The wedges are $1 + \tau_{ma}$ and $1 + \tau_{sa}$ distortions not explained by the benchmark model.

which is manufacturing intensive, a limited competition that restricted trade of manufactured goods, and the costs of reallocation out of agriculture as well as non-market compensation in that sector (such as housing and subsistence food production), among many others.

6. Decomposition

In this section, we use the model (with wedges) to decompose the change of manufacturing and services labor allocations relative to agriculture, L_m/L_a and L_s/L_a , respectively. We compute how much of the change was due to the supply-side drivers (unequal productivity growth), demand-side drivers (income growth), and the labor market distortions. We use the logarithm of equation (14) to decompose these different sources. Consider the notation $\Delta z_t = z_t - z_{t-1}$ for any variable z , we have for $i \in \{m, s\}$:

$$\Delta \ln \left(\frac{L_i}{L_a} \right) = (1 - \sigma) \Delta \ln \left(\frac{A_a}{A_i} \right) + (\epsilon_i - \epsilon_a) \Delta \ln(C) - \sigma \Delta \ln(1 + \tau_{ia}) \quad (25)$$

and the sources of relative labor allocation are given by (25). The first term $(1 - \sigma) \ln(A_a/A_i)$ captures the supply-side effect, the demand-side effect is given by $(\epsilon_i - \epsilon_a) \ln(C)$ and the wedge effect is $(-\sigma)(1 + \tau_{ia})$. Because the economy behaves so differently before and after 1980, we decompose the sources of relative labor changes in these two sub-periods separately.

In Figure 4(a), we observe that the productivity in agriculture grows slower than in manufacturing until the mid-1970s. If household preferences were homothetic, $\epsilon_i = 1 \forall i \in \{a, m, s\}$, labor should actually be allocated towards agriculture as a way to compensate for the larger difference of manufacturing productivity relative to agriculture and satisfy balanced consumption. Until the mid-1970s, the supply effect induced labor in the opposite direction of what is observed in the data. This effect is illustrated in Figure 7(a) by the decrease in the supply effect (dashed line). The demand effect (dash-dotted line) is the main driver of the increase in L_m/L_a . In the absence of supply effects or distortions, the relative labor would actually be higher than the data. From Figure 6, we see that the wedge $\tau_{ma} > 0$. It indicates that, despite the fast growth of labor share in manufacturing, this growth should have been even faster given the large productivity increase observed.

Now we turn to the decomposition of labor towards the services sector. During the first sub-period, there is only a small increase in the relative productivity of agriculture with respect to services. Even though the supply effect induces labor towards services, the effect is quantitatively small. As in the manufacturing sector, the demand effect plays a major role. From Figure 7(b), we see the importance of the demand effect and the minor role of the supply effect. For the entire 1950–1980 period, the wedge effect would induce a decline in the services labor. In Figure 6,

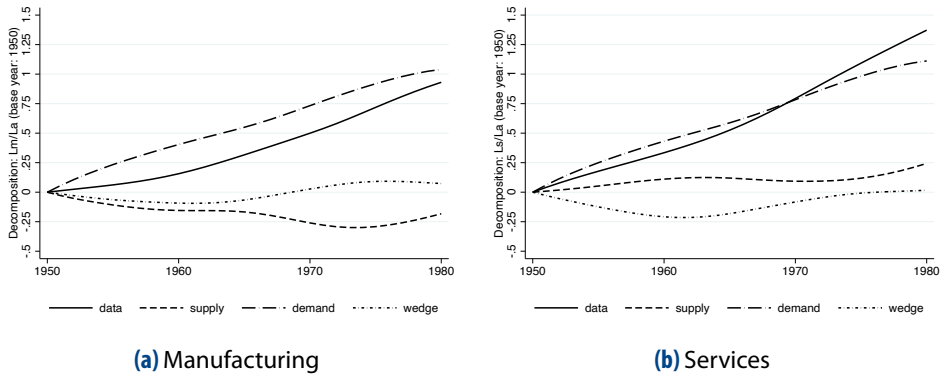


Figure 7. DECOMPOSITION: 1950–1980

Panel (a) plots decomposition of manufacturing relative labor L_m/L_a . Panel (b) plots decomposition of services L_s/L_a . For both sectors, the demand driver is the main force to explain relative labor allocation.

one can see that $\tau_{sa} > 0$ until the late 1970s, acting as a tax on labor demand in the services sector.

Figure 8 plots the decomposition of labor in manufacturing and services relative to agriculture for the following sub-period, 1980–2010, where the variables are now normalized to their 1980 levels (including the wedges). During the second sub-period, we see significant changes in relative productivity. Again, the supply effect turns out to be the primary source of labor reallocation for both sectors.

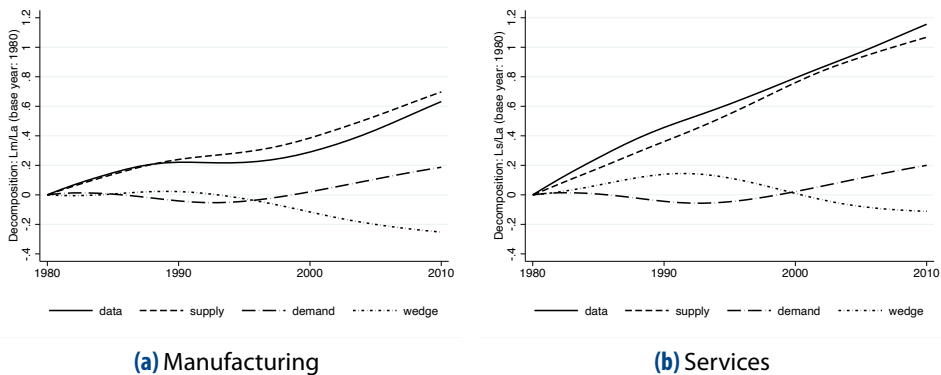


Figure 8. DECOMPOSITION: 1980–2010

Panel (a) plots decomposition of manufacturing relative labor L_m/L_a . Panel (b) plots decomposition of services L_s/L_a . For both sectors, supply effect is the main force to explain relative labor allocation, but income is also important.

In Table 4, we present the decomposition of manufacturing labor relative to agriculture averaged over different periods and the results represent the average growth rate.²² The demand effect is the most important force for the allocation of labor between manufacturing and agriculture for the entire 1950–2010 period. The demand effect is responsible for 78.5% of the increase in relative labor. For the first sub-period, the demand effect is actually higher than one and equal to 111.7%; that is, if there was no decrease in relative productivity of agriculture with respect to manufacturing, relative labor $\ln(L_m/L_a)$ would be higher than observed. In the second sub-period 1980–2010, the importance of the demand effect is much lower than the supply effect. In this sub-period, demand effect is responsible for 29.6%, whilst supply effect for 110.3%.

Table 5 presents the decomposition results for the services sector. The demand and supply effects are equally responsible for the change in relative labor allocation, each accounting for 51.8%. In the first sub-period from 1950 to 1980, its contribution is equal to 81.0%. In the second sub-period, the demand effect is lower than the supply effect. Demand effect is responsible for 17.3% and supply effect for 92.4%. Thus, again, the wedge effect has a small impact.

Table 4. DECOMPOSITION: MANUFACTURING

This table shows the average growth of manufacturing labor relative to agriculture. It decomposes the quantitative importance of supply, demand and wedge effects in the allocation of labor for different period intervals. Supply effect is $(1 - \sigma) \ln(A_a/A_m)$. Demand effect is $(\epsilon_m - \epsilon_a) \ln(C)$. Wedge effect is $(-\sigma) \ln(1 + \tau_{ma})$. The values in parenthesis indicate the relative contribution of each effect.

	Labor	Supply	Demand	Wedge
1950–2010	0.0256	0.0084 (0.3295)	0.0201 (0.7849)	-0.0029 (-0.1144)
1950–1980	0.0300	-0.0058 (-0.1960)	0.0335 (1.1171)	0.0023 (0.0789)
1980–2010	0.0204	0.0225 (1.1034)	0.0060 (0.2958)	-0.0081 (-0.3993)

²²Sector *i* average for each subperiod of size *T* is

$$\frac{\ln(L_{i,t+T}/L_{a,t+T}) - \ln(L_{i,t}/L_{a,t})}{T} = (1 - \sigma) \frac{\ln(A_{a,t+T}/A_{i,t+T}) - \ln(A_{a,t}/A_{i,t})}{T} + (\epsilon_i - \epsilon_a) \frac{C_{t+T} - C_t}{T} - \sigma \frac{\ln(1 + \tau_{ia,t+T}) - \ln(1 + \tau_{ia,t})}{T}.$$

Table 5. DECOMPOSITION: SERVICES

This table shows the average growth of manufacturing labor relative to agriculture. It decomposes the quantitative importance of supply, demand and wedge effects in the allocation of labor for different period intervals. Supply effect is $(1 - \sigma) \ln(A_a/A_s)$. Demand effect is $(\epsilon_s - \epsilon_a) \ln(C)$. Wedge effect is $(-\sigma) \ln(1 + \tau_{sa})$. The values in parenthesis indicate the relative contribution of each effect.

	Labor	Supply	Demand	Wedge
1950–2010	0.0415	0.0215 (0.5187)	0.0215 (0.5188)	-0.0015 (-0.0375)
1950–1980	0.0443	0.0078 (0.1775)	0.0358 (0.8101)	0.0005 (0.0122)
1980–2010	0.0373	0.0344 (0.9237)	0.0064 (0.1729)	-0.0036 (-0.0966)

7. Counterfactuals

In this section, we use the model (with wedges) for computational experiments to gain more insight into the different factors driving the process of structural transformation in Brazil. If we compute the labor allocation paths of the model when all exogenous variables (including wedges, sectoral productivities and consumption index) are set to the values observed in the data, the model matches the data exactly. In the counterfactual exercises, we quantify the contributions of productivities by removing one at a time and checking their effects in the relevant variables such as aggregate productivity and manufacturing labor share.²³ We focus on the manufacturing labor share because matching the model to data in this sector is particularly challenging due to its non-monotonic behavior. Moreover, many of the Brazilian policies implemented during the period studied have aimed at stimulating production in this sector.

To perform the counterfactuals, we first calculate the labor share in agriculture L_a/L using equation (13)²⁴ after substituting the consumption index C as a function of L_a/L from equation (18). Once the counterfactual series of labor share in agriculture L_a/L is determined, we calculate the counterfactual consumption index C using equation (18). Finally, we compute labor shares using equation (13) again.

²³In the Appendix, we also plot the labor shares for the other sectors, and the consumption index.

²⁴Notice that equation (13) with the wedges is

$$\frac{L_i}{L} = \frac{(1 + \tau_i)^{-1} \Omega_i p_i^{1-\sigma} C^{\epsilon_i}}{\sum_i (1 + \tau_i)^{-1} \Omega_i p_i^{1-\sigma} C^{\epsilon_i}}$$

where $p_i = (1 + \tau_i)/A_i$. Since only the relative wedges matter we set $\tau_a = 0$ in the counterfactual exercises.

In the first counterfactual, we explore the effects of manufacturing productivity A_m in the economy. We find that the fast growth of manufacturing productivity in Brazil compared to the U.S. accounts for aggregate productivity being 14.3% higher in 1980. In the second counterfactual, we discuss the importance of manufacturing and services productivities after 1980. Our main finding is that the low productivity in the services sector is the main driver of the decline in the labor share of the manufacturing sector and for the stagnation of aggregate productivity.

7.1 Counterfactual 1: The Role of Manufacturing Productivity

The first counterfactual exercise evaluates the impacts of the manufacturing productivity A_m on labor allocation and aggregate productivity. The main motivation for this counterfactual is the fast growth of manufacturing productivity in Brazil from 1950 to 1980. Recall from [Table 3](#) that, in this period, the average manufacturing productivity growth rate in Brazil was 3.47% while in the U.S., it was 1.63%. In the second sub-period, we observe that the average growth rate in Brazil was just 0.37%, while in the U.S., it was 2.07%. In this counterfactual, we evaluate how Brazil's fast-paced manufacturing productivity growth relative to the U.S. affected the economy. We feed the model with the wedges computed in the previous section, aggregate labor, and observed productivities in agriculture and services for Brazil. To determine the effect of the growth of the Brazilian manufacturing productivity, we replace it with the average productivity growth rate of 1.87% observed in the U.S.

In 1980, the aggregate productivity in the counterfactual economy is equal to 85.7% of the level observed in the data. Of the observed aggregate productivity level in 1980, 14.3% comes from the fast growth in manufacturing productivity. The lower productivity in the counterfactual also induces a higher allocation of labor towards manufacturing since lower productivity, together with preference for balanced consumption, $\sigma < 1$, generates a higher allocation of labor in the manufacturing sector as a way to meet demand. We see in [Figure 9](#) that the labor share in manufacturing would be significantly higher than observed in the data. In the counterfactual economy, manufacturing labor share peaks in 1980 at 29.5%, whereas in the data, the peak happens in 1983 at 23.0%. Finally, the fast growth results on an aggregate consumption, C , 7.5% larger in the data than in the counterfactual in 1980 (see [Figure 13](#) at page 494).

In the second sub-period, aggregate productivity in the counterfactual economy catches up to the observed due to the sluggish behavior of manufacturing productivity in Brazil after 1980. Also, in 2010, the manufacturing labor share would be 21.1%, close to 20.5% observed in the data. Lastly, aggregate consumption in the counterfactual is 0.5% lower than observed in the data.

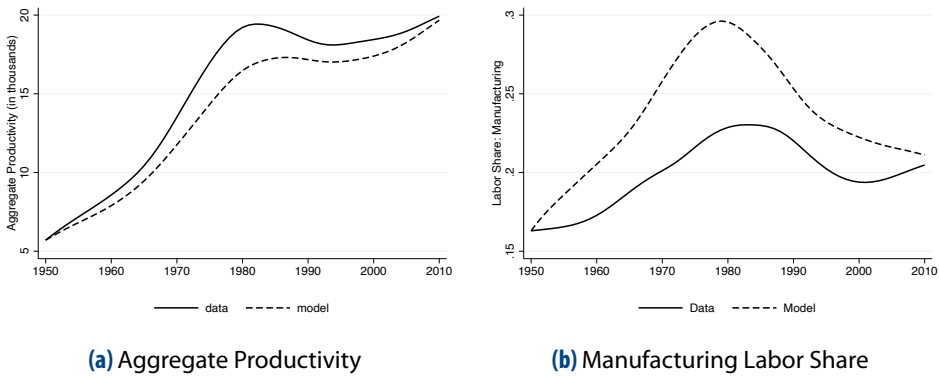


Figure 9. COUNTERFACTUAL 1

Panel (a) plots aggregate productivity if manufacturing labor productivity behaved as in the U.S. Panel (b) plots the manufacturing labor share in the data and the counterfactual. A lower than observed growth in manufacturing productivity implies a higher share of labor in the manufacturing sector.

7.2 Counterfactual 2: Stagnation and the Role of Productivities

The second counterfactual concentrates on the stagnation of the Brazilian economy during the second sub-period. As previously discussed, between 1980 and 2010, manufacturing productivity stood almost still, and services productivity declined, see Figures 3 and 4. Therefore, we conjecture that the decline in services productivity was particularly detrimental to the Brazilian economy. And to evaluate its importance, we assume it remains constant at its 1980 level for the rest of the period.²⁵ For completeness, at the end of this section, we also discuss the results for this counterfactual fixing manufacturing productivity constant instead.

The results displayed in Figure 10 show that the deterioration of services productivity had major repercussions for the Brazilian economy. As an illustration, the counterfactual economy manufacturing labor share in 2010 equals 24.6% whilst it equals 20.4% in the data. Likewise, by 2010, aggregate productivity would be 27.6% higher than observed in the data.²⁶ This significant effect in aggregate productivity is observed because the drop of productivity occurred in a large and growing sector of the economy. Furthermore, the aggregate consumption index in 2010 would be 13%

²⁵We do consider the behavior of the labor productivity in the services sector after 1980 a striking feature of the Brazilian economy. However, despite its intriguing behavior, we do not take a stand on what explains it in this paper, restricting ourselves to account for its impact.

²⁶Labor productivity observed in 2010 equals \$19,931 (2005 local prices). In the counterfactual, it reaches \$25,430 (2,005 local prices).

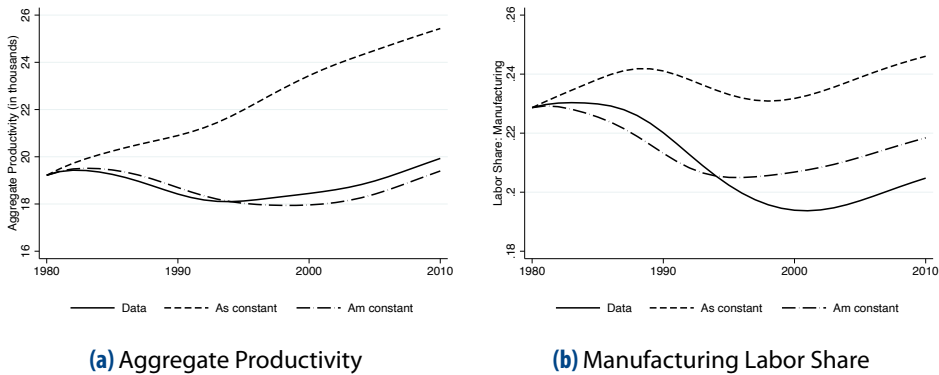


Figure 10. COUNTERFACTUAL 2

Panels (a) and (b) plots the data and two counterfactuals. One counterfactual assume services productivity A_s constant at 1979 level (dash line) and the other assume manufacturing productivity A_m at 1979 level (dash-dot line).

higher than in the benchmark.²⁷ Thus, by simply not declining, services productivity has considerable effects in the economy.

On the other hand, if manufacturing productivity had been constant at its 1980 level, manufacturing labor share and aggregate productivity would have had a behavior very similar to the observed in the data. In 2010, aggregate productivity would have been only 2.7% lower; that is, 97.3% of the data level. Thus, the impact on manufacturing labor would also be small, reaching 21.8% in the counterfactual, which confirms our conjecture that services productivity was crucial in determining the observed aggregate productivity path while manufacturing productivity had a secondary role.

Premature deindustrialization

The U.S. and other developed countries have experienced the process of deindustrialization for decades, with the shares of labor and value added in the U.S. manufacturing sector have steadily declined since the 1950s. For example, labor share in manufacturing declined from 33.4% in 1950 to 15.1% in 2010, and value added share declined from 30.5% to 18.5%.

In contrast, Brazil experienced a monotonic increase in manufacturing labor share from 1950 to 1983. This period is also characterized by the implementation of protective policies such as import substitution, which advocates replacing imports for domestic production and prohibiting the imports of goods for which there were a “national similar”. These policies had the explicit goal of increasing activity in the domestic manufacturing sector. After its peak in 1983, labor share in manufacturing

²⁷In the benchmark, the consumption index C is 5.13 and in the counterfactual is 5.80.

decreased until the early 2000s, followed by a mild increase. A well-documented structural transformation fact is the inverted U-shaped path of manufacturing labor share over the course of development.²⁸ Even though such a pattern can be observed in developing countries, including Brazil, the turning point of the Brazilian manufacturing labor share happens at a much lower level of income than observed at countries that industrialized earlier such as the U.S. and some European countries. This turning point at lower levels of income is the so-called premature deindustrialization (Rodrik, 2016). From our analysis, it is unclear if the 2000s mild increase of the manufacturing labor share is only a temporary phenomenon or if it will ever reach the levels observed in the early industrialized countries.

In our model, a decline in services productivity, A_s , reallocates labor away from agriculture and manufacturing—and towards services—due to consumption complementarity. With more labor in the services sector, services productivity has a larger weight on aggregate productivity levels. As the counterfactual indicates, services productivity is crucial in explaining the manufacturing labor share and aggregate productivity after 1980. From the lens of our model, the premature deindustrialization in the Brazilian economy is mostly due to the low productivity in the services sector, as firms in this sector require much more labor to meet demand.

An increase in manufacturing productivity, A_m , has two enforcing effects that push labor away from the manufacturing sector towards services. Higher manufacturing productivity reallocates labor towards services due to the preference for balanced consumption, $\sigma < 1$, and due to the high income elasticity, $\epsilon_s > \epsilon_m$. In the counterfactual exercise with A_m constant, the impacts on manufacturing labor share were very limited. The results of the counterfactual exercises suggest that the behavior of manufacturing productivity A_m is not the primary cause of the drop of manufacturing labor share observed since the 1980s.

8. Conclusion

This paper studies the Brazilian structural transformation process between 1950 and 2010. We use a framework that accommodates both long-run demand and supply drivers of labor reallocation. We decompose the sources of structural transformation for the 1950–2010 period. We find that the demand effect is the most important driver for the relative allocation of manufacturing labor with respect to agriculture. Demand and supply effects are both quantitatively important for the relative allocation of services to agriculture. However, the result depends on the sub-period of analysis. If we focus on the 1950–1980 period, the demand effect is the crucial driver. If we focus only on the 1980–2010 period, the supply effect is then the most important driver. The distortions captured by the wedge effect had a minor impact on relative

²⁸See Herrendorf et al. (2014) for a thorough discussion of the structural transformation facts.

labor allocation for the entire period. During the catching-up period, we find that fast manufacturing productivity growth was responsible for 14.3 % of the aggregate productivity level in 1980. We also find that the decline in services productivity is the crucial determinant for the stagnation period after 1980. If services productivity had simply stayed constant at its 1980 level, aggregate productivity would be 27.6 % higher in 2010.

The model used in this paper considers labor as the only input of production and ignores capital stock. However, many of the policies observed had the clear objective of increasing the capital accumulation in the country. Therefore, our next research step is to consider a model with an endogenous inter-temporal choice that allows us to compute the effects of policies that distorted the increase of capital stock.

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Appendix.

Decomposition 1950–2010

Figure 11 plots the decomposition for the entire 1950–2010 period. Between 1950–1980 the demand effect follows very closely the data. After 1980, its slope is much smaller and it doesn't follow the data so closely anymore. This change motivates our decision of making the decomposition exercise in two different sub-periods. It is also clear that the wedges have just a small effect on labor allocation. Notice that, if analyzed for the entire period, demand and supply effects account for the same in the services sector.

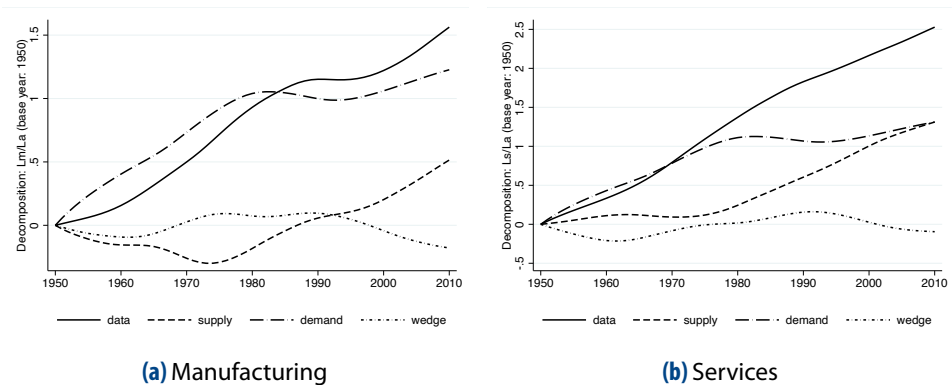


Figure 11. DECOMPOSITION: 1950–2010

Panel (a) plots decomposition of manufacturing relative labor L_m/L_a . Panel (b) plots decomposition of services L_s/L_a . Demand is the most important force between 1950 and 1980. After 1980, supply becomes the most important.

Consumption Index

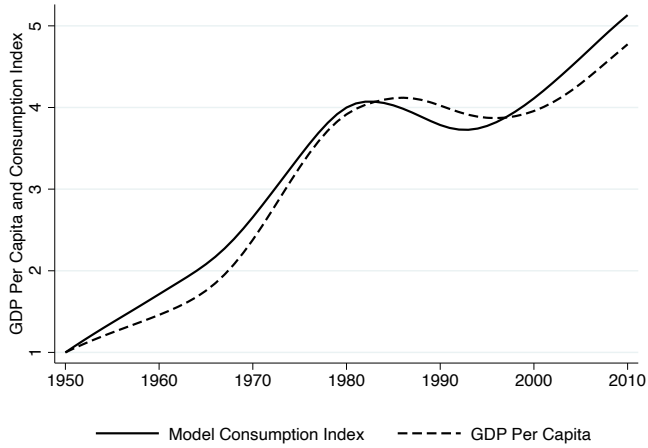
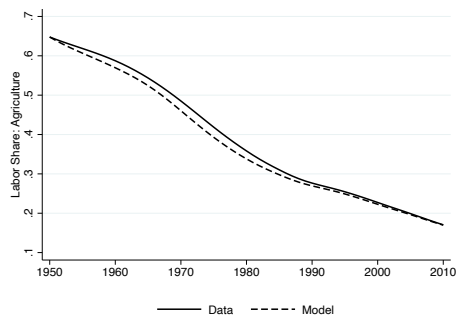


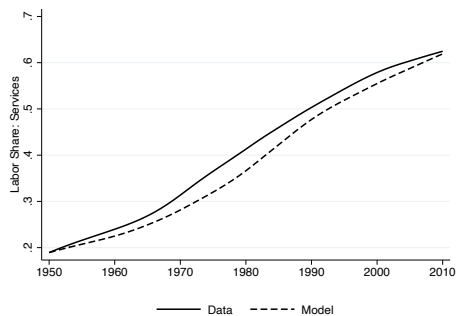
Figure 12. CONSUMPTION INDEX AND GDP PER CAPITA

We compare the behavior of GDP per capita normalized for 1950 and the consumption index C computed using equation (18).

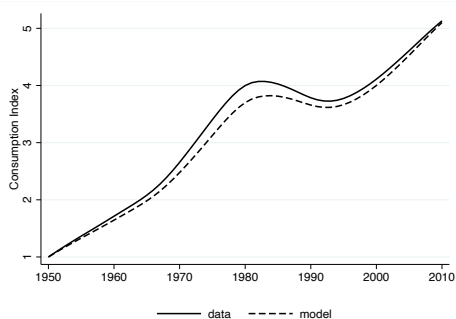
Counterfactual 1



(a) Labor Share: Agriculture



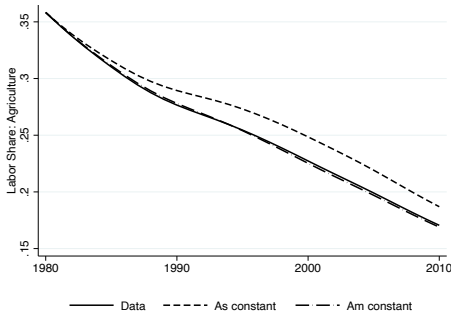
(b) Labor Share: Services



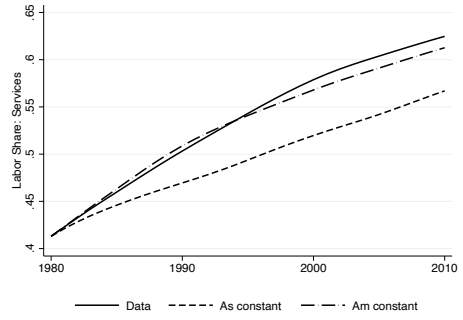
(c) Consumption Index

Figure 13. Counterfactual 1

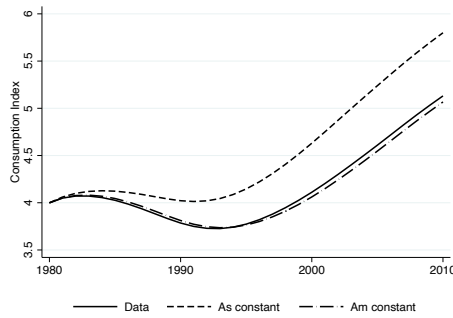
Counterfactual 2



(a) Labor Share: Agriculture



(b) Labor Share: Services



(c) Consumption Index

Figure 14. Counterfactual 2