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Structural Transformation and Productivity in Latin America*

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Abstract

This article examines the effects of sectorial shifts and structural transformation on the recent productivity path of Latin America. We use a four-sector (agriculture, industry, modern services and traditional services) general equilibrium model calibrated to the main economies in the region. The model very closely replicates labor reallocations across sectors and the growth of aggregate labor productivity from 1950 to 2005. Structural transformation explains a sizeable portion of the region's convergence in the first decades. In most cases, the poor performance of the traditional services sector is the main cause of the slowdown in productivity growth observed in the region after the mid-1970s and is a key factor in explaining the divergence during this period.

Key-words: structural transformation; labor productivity; service sector.

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1 Introduction

It is commonly accepted that there is a large disparity in the development experiences of countries around the world. While many nations experienced a rapid increase in output per worker in recent decades, others lost ground compared with the leading economies. Latin America is a well-known case of relative stagnation or divergence. What is most remarkable is that until the mid-1970s, almost all of the economies in the region experienced high productivity growth, reducing the gap with respect to developed economies. However, except for Chile, there was a dramatic decrease in growth after this convergence period, and in most cases, the relative productivity in 2005 is similar or even lower than that verified for 1950. For example, output per worker for Mexico relative to the U.S. increased from 40% in 1950 to 60% in 1976 but then fell to only 38% in 2005. In Brazil, the movement was similar, with relative productivity increasing from 16% to 33% from 1950 to 1980 but falling to 23% by 2005.

At the same time, a rapid process of structural transformation and a reallocation of labor across sectors can be observed in the region. While the leading countries after WWII were already urban economies with economic activities concentrated in manufacturing and services, most of the countries in Latin America were still rural economies. In Brazil, Mexico and Colombia, for example, more than 50% of the working population was in agriculture in 1950. In most cases, by the mid-1970s and still in 2005, the labor distribution across sectors was very different and, with very few exceptions, less than 20%-25% of the working population was in agriculture. In contrast, the share of services in the working population and in value added increased markedly in all countries in the region, reaching more than 60% of the total employment in most cases.

Certain aspects of economic development may be linked to this reallocation process. Obviously, aggregate productivity is the sum of sectorial productivities, weighted by the share of workers employed in each sector. Thus, the shift of workers from a less-productive sector (e.g., agriculture) to a more productive sector (e.g., manufacturing or services) increases the overall productivity of the economy. However, once this process - or most of it - is completed, the path of overall productivity depends chiefly on the productivity growth of each sector. Hence, the fact that labor productivity in services in certain Latin American economies fell or slowed dramatically in the 1980s and 1990s, at the same time that the relative importance of the sector increased, may explain a sizeable portion of the region's stagnation.

In this article, we analyze the relative productivity path of Latin American countries from the perspective of structural transformation. Although our data set begins in 1950 and we implement some exercises with the data from the convergence period, our main interest is to investigate the most recent period. More precisely, we want to understand and measure the contribution of the different sectors to the decrease in relative productivity observed in these countries over the last 20 to 30 years.

We use a very simple four-sector (agriculture, industry, modern services and traditional services) general equilibrium model that is calibrated for nine countries in the region. The model very closely replicates labor reallocation across sectors and the growth of aggregate labor productivity from 1950 to 2005. We then perform counterfactual exercises for each country to quantify the relative importance of each sector to the productivity slowdown. For example, in one exercise we first estimate what the relative productivity would have been had all of the sectors grown over the entire 1950-2005 period at the rates observed during the convergence sub-period. In the case of Brazil, for example, output per worker would be 48% instead of 23% of the output per worker in the U.S. Then, keeping productivity growth in three sectors constant and equal to the growth during the convergence period, we change the productivity growth in the fourth sector to that observed in the data. For most economies, by far the strongest impact is due to the decline in the productivity of traditional services. In the case of Brazil, relative output per worker falls from 48% to 34% in the simulation for the traditional service sector and to 39% in the case of manufacturing.

The relationship between economic development and structural change was first examined by Kuznets (1966) in the mid-1960s and by Chenery (1975), Kuznets (1971) and Rostow (1971) in the early 1970s. In this article, we follow a more recent strand of the literature that combines the influence of international income differences with the delay in the structural transformation process. For example, the works of Duarte and Restuccia (2005), Duarte and Restuccia (2010), and Echevarria (1997) explain the reasons why some countries achieve exceptional increases in productivity while others only widen the productivity gap compared with more developed economies, while Herrendorf and Valentinyi (2012) investigate which sectors make poor countries unproductive. Our model is close to Duarte and Restuccia (2010) and Rogerson (2005), but we added two subsectors to services that are fundamental to understanding Latin America low growth. Moreover, although we used similar data than the former article, most of our exercises - e.g., the comparison to South Korea experience - are new, as is the result that the productivity slowdown of traditional services is the main cause to the slowdown of aggregate productivity in many Latin American economies.

Numerous studies have examined the recent growth slowdown in Latin America (e.g., Cole, Ohanian, Riascos and Schmitz (2005), Loayza, Fajnzylber and Calderón (2005), Blyde and Fernandez-Arias (2006) and Ferreira, Pessôa and Veloso (2013)). To our knowledge, this is the first article to investigate the link between structural transformation and the stagnation in Latin America in the 1980s and 1990s. We find that the sectorial effects are very important for explaining the recent development experience in Latin America, and the performance of the tertiary sector is the key to understanding it.

The paper is organized into four sections in addition to this introduction. In Section 2, we present the main stylized facts on growth and structural transformation in Latin America, including a decomposition based on McMillan and Rodrik (2011). The model and the calibration procedure are presented in Section 3, and in Section 4 the results are presented and discussed. Section 5

concludes.

2 Stylized Facts

2.1 Data

The main data sources are the Penn World Table and the Groningen Growth Development Centre 10-Sector Database¹. The period considered is from 1950 to 2005 for all countries except Chile, Peru and Bolivia, whose series data are available for only part of the sample².

Each sector of activity is defined according to the international standard classification of economic activities in the statistical division of the United Nations (ISIC 3), in which the agricultural sector comprises forestry, fisheries and agriculture; the industrial sector comprises mining, extraction, manufacturing, utilities and construction; and the services sector comprises wholesale and retail, hotels, restaurants, transport, storage, communications, finance, insurance, real estate, personal services, social services, and community services. In the service sector, the modern services comprise transport, storage, communications, finance, insurance and real estate while the traditional services group is composed by retail, hotels, restaurants, personal services, social services and community services.

This break down of the service sector is not uncommon in the economic development literature. For example, the article by Rogerson (2005) splits the activities of the service sector into market services and non-market services. In this article, we consider the level of productivity of the sectors to make this distinction. Modern services are those sectors with higher labor productivity, while traditional services are ones with lower levels of labor productivity in 2005³. Accordingly, we aim to identify within the services sector which are the sectors whose the behavior of labor productivity is more similar to the labor productivity dynamic of the industrial sector.

We also used Brazilian household survey data⁴ to double check our classification. For 2002 and 2007, we ran OLS regressions of personal income on sector dummies and controls such as education, gender and region. Although the sector classification is not exactly the same as that used in the Groningen dataset, it is similar enough. In both years, and either using hourly wages or monthly wages, income in the wholesale, retail, restaurants, hotels and domestic services sectors is always statistically significant below that of manufacturing. In contrast, income in the transport

¹See Timmer and de Vries (2009). For the United States, the data for employment and value-added are taken from the Bureau of Economic Analysis of the U.S. Department of Commerce.

²For Peru, the series data cover the period from 1960-2005. For Chile, the series data cover the period from 1951-2005. For Bolivia, the series data cover the period from 1950-2003.

³For example, in 2005, labor productivity in "Wholesale and Retail Trade, Hotels and Restaurants" and "Community, Social, Personal and Government Services" sectors were only 58% and 53% of that of manufacturing. In contrast, that of the "Finance, Insurance, Real Estate and Business Services" was 63% higher, and in the transportation sector it was close but still 20% higher.

⁴From the "PNAD", Pesquisa Nacional por Amostra de Domicílios.

and communication sectors was above the income in manufacture, but in some regressions this difference was not statistically significant. In the finance, insurance and real estate sector, income was well above (and statistically significant) than in manufacturing. This result reinforces our division of the services sector between a "traditional" and less-productive sector and a "modern" sector in which productivity is close to, or above, that of manufacturing.

The absolute productivity is calculated as the ratio of the value added, in real terms, in the currency of each country to the total number of employees in each country. The relative productivity is calculated as the ratio of the absolute productivity of each country, adjusted for Purchasing Power Parity (PPP), to the absolute productivity in the United States, also adjusted for PPP. Because no data are available for the value added adjusted for PPP in each sector, the relative productivity of each sector is determined by the model. We use the model to back out sector-specific PPP conversion factors across countries in the initial period (1950), and use the data on growth rates of labor productivity in local units (constant price) to construct the time series for productivity that we feed into the model.

2.2 Labor reallocation

From Figures 1 and 2 it is clear that all Latin American economies experienced a strong process of labor force reallocation, with steep decreases in the participation in agriculture and an increase in the share of labor in services:

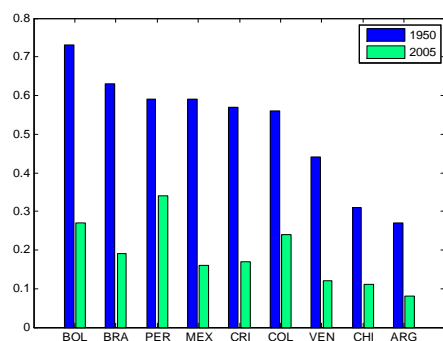


Figure 1: Labor Share in Agriculture

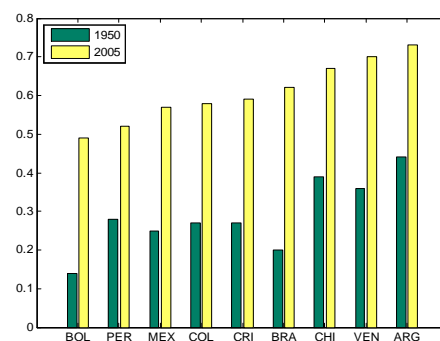


Figure 2: Labor Share in Services

In most cases, these Latin American economies are in an earlier stage of structural transformation compared to developed economies, although each country is going through different phases of the labor reallocation process. In most countries (e.g., Brazil, Mexico, Chile and Venezuela), the percentage of workers employed in agriculture was between 10% and 20% in 2005 (Figure 1), but this percentage was less than 10% in some countries (e.g., Argentina, 7.7%) and greater than 20%

in others (e.g., Colombia, 24%) in the same year. Likewise, the percentage of workers employed in services in 2005 was close to 70% in certain countries (e.g., Argentina, Chile and Venezuela) and closer to 60% in others (e.g., Brazil, Colombia, Costa Rica and Mexico). In Bolivia and Peru, the share of employees in agriculture in 2003 and 2005 was relatively high (27% and 34%, respectively), and the percentage of employees in the service sector was low (49% and 52%, respectively).

In the service sector, most of the workforce was in the group of traditional services in 2005. While the share of workers in traditional services in 1950 ranged from 12% (Bolivia) to 34% (Argentina), this percentage increased significantly between 1950 and 2005, with all countries of the region showing a percentage of workers in the traditional service sector above 40% in 2005. In some countries (e.g., Brazil, Argentina and Venezuela), the figure surpassed 50% in 2005.

Some countries that had a large share of employees in services and a small share in agriculture in 2005, such as Argentina, Chile and Venezuela, began the process of structural transformation earlier than others. Nevertheless, the composition of labor observed in more developed economies (e.g., the United States) suggests that the process of labor reallocation is likely to continue in these economies. For example, the share of workers employed in agriculture in the United States was 1.6% in 2005, while the percentage of workers employed in services was 80.9%.

2.3 Aggregate Productivity

Growth in Latin America during the period from 1950-2005 can be divided into two parts. Until the middle to the end of the 1970s, the economies in the region experienced high productivity growth, reducing the gap with respect to the developed economies⁵. However, except for Chile, there was a dramatic decrease in growth after this period, and in most cases, labor productivity relative to the U.S. in 2005 was below or close to the 1950 levels.

Table 1 presents Latin American labor productivity relative to the U.S. in 1950, 2005 and in the year in which relative productivity "peaked" in each country⁶. Brazil and Mexico exhibited a strong acceleration in relative productivity from 1950-1980. Relative productivity in Brazil increased from 0.16 in 1950 to 0.33 in 1980, while relative productivity in Mexico increased from 0.40 in 1950 to 0.60 in 1976. In the following years, however, these countries experienced a significant decline in labor productivity, with the relative productivity in 2005 falling to 0.23 in Brazil and 0.38 in Mexico. In other cases, such as in Costa Rica, Peru and Venezuela, there was also a catch-up period in the early years of the sample. However, this process was shorter, lasting only until the early 1970s.

Colombia, unlike the other countries, did not go through a period of productivity convergence

⁵Only Venezuela had its catch-up process interrupted before this date, more precisely in 1970. In Bolivia, relative productivity declined throughout the period.

⁶Because our goal is to understand the trend of the relative productivity measure, we use the HP filter to "extract" the fluctuations in the data due to the business cycle. The peak in this case is the maximum value of the relative productivity trend.

between 1950 and 2005. Until 1990, Colombia's relative productivity remained stagnant, with a strong decrease in the following years. In Argentina, relative productivity increased from 0.40 in 1950 to 0.42 in 1975. Despite the small increase in comparison to other Latin American economies, relative productivity exhibited an increase of 4 percentage points during the period from the trough (0.38 in 1955) to the peak of 0.42 in 1975. Among the countries considered, Venezuela exhibited the strongest decline in relative productivity in recent years: relative productivity increased from 0.55 in 1950 to 0.68 in 1970, but then it collapsed to 0.28 in 2005.

The only country that experienced an increase in relative productivity in recent years was Chile. Despite its decline in the early years of the sample, Chile's relative productivity increased from 0.27 in 1985 to 0.34 in 2005.

Table 1: Relative productivity

	Relative Productivity			Peak's year
	1950	Peak	2005	
Argentina	0.40	0.42	0.32	1975
Bolivia	0.21	0.21	0.12	1950
Brazil	0.16	0.33	0.23	1980
Chile	0.30	0.35	0.34	2000
Colombia	0.26	0.28	0.19	1976
Costa Rica	0.34	0.45	0.28	1971
Mexico	0.40	0.60	0.38	1976
Peru	0.27	0.34	0.21	1974
Venezuela	0.55	0.68	0.28	1970

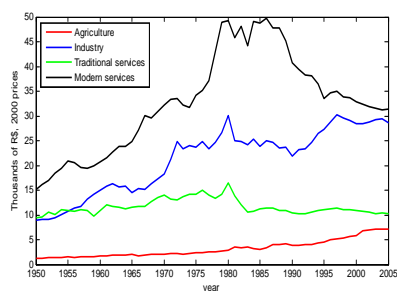
2.4 Sectorial productivity

Figure 3 presents the sectorial productivities of six economies. With the sole exception of Venezuela, industrial productivity increased during the entire period in all of the economies. From 1950 to the mid-1970s or 1980, industrial productivity increased very rapidly. From 1950 to 1980, for instance, manufacturing⁷ productivity grew by 4.2% per year in Brazil. In Argentina, manufacturing productivity grew by 2.1% per year from 1950 to 1975, and it grew by 3.1% per year over the same period in Colombia. Similar figures are observed for Chile and Mexico. Note, however, that productivity growth in this period was rapid in all sectors of all countries. This fast and generalized productivity growth, combined with the reallocation of labor across sectors, explains the convergence observed during the period.

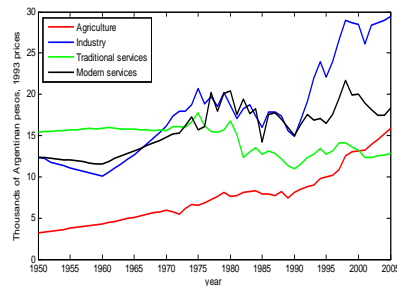
Another important aspect of productivity of these countries is the difference between the trajectories of productivity in modern and traditional services. By construction, in all countries

⁷We use the terms industry and manufacturing interchangeably throughout the paper.

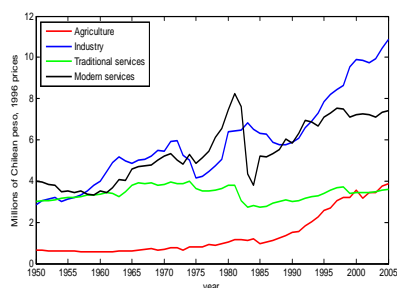
analyzed, the level of productivity of modern services in 2005 is superior to that of traditional services. However, while productivity in modern services grew at least in some periods, and in most cases it end up increasing from 1950 to 2005, the productivity of traditional services remained stagnant or declined in all economies, when considering the entire period. That is a potential problem because the latter represents a larger share of total workers in these economies.



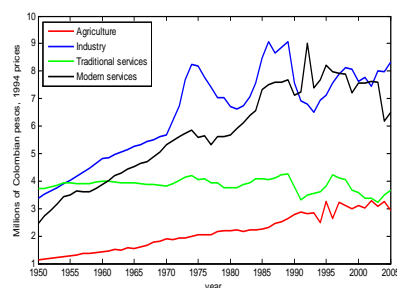
Brazil



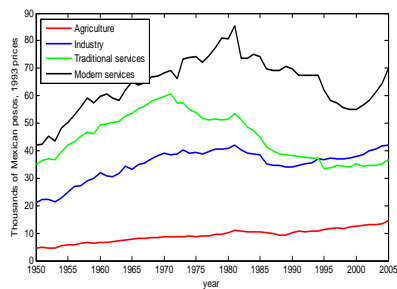
Argentina



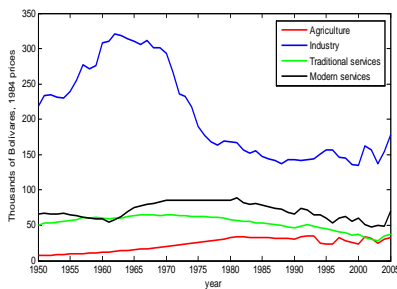
Chile



Colombia



Mexico



Venezuela

Figure 3: Sectorial Productivity in Latin America

A decomposition of the stagnation after the peak years is more subtle. In Brazil, for example, manufacturing productivity in the 1981-2005 period slowed significantly to 0.6% per year, and productivity growth in traditional services decreased by -1.2% while productivity growth in modern services dropped by a shocking -1.6% per year, although the productivity of the agricultural sector continued to grow strongly. Taking into account the reduction in labor share for manufacturing and considering that the labor share for traditional services reached more than 50% of the labor force, it is easy to understand the reversion of the Brazilian catch-up process. After 1975 in Argentina, there was a slight slowdown in manufacturing productivity (from 2.1% to 1.6%), but productivity growth in services was negative (it decreased from 0.6% to -0.5%), mainly due to the contraction in productivity of traditional services (-0.8% per year in the period).

The productivity trends also changed in approximately 1975 for Colombia. Colombia's manufacturing productivity did not grow at all after 1975, and productivity in services declined by -0.1% annually (-0.4% in the traditional services and 0.4% in the modern services). Agricultural performance was not poor, but if one considers that the labor share for the sector decreased from 56% to 24% between 1950 and 2005, it is obvious that the agricultural sector's impact on overall productivity was small. The Mexican case is similar to Colombia in the sense that, after a period of rapid growth, manufacturing and services experienced a strong productivity decline.

Chile is the only country in the sample in which the productivity in services grew over the last two decades. In fact, Chile experienced rapid growth in all three of the sectors during this period, with agriculture reaching an impressive 7.1% per year, manufacturing 2.7%, traditional services 1.4% and modern services 1.8%. Thus, Chile's recent catch-up process was a result of the efficiency of the economy as a whole. In Venezuela, in contrast, all of the sectors contributed to the productivity decline: from 1971 to 2005, the annual growth rates in manufacturing, traditional services and modern services were -1.2%, -1.6% and -0.6%, respectively.

2.5 Structural transformation

The study of the process of structural transformation is important to understand the different productivity paths in these countries in recent years. As we shall see, the reallocation of labor from agriculture to more productive sectors (e.g., industry and services) explains a significant share of the productivity gains in several of the Latin American economies between 1950 and 2005. Even in countries that exhibited a strong decline in productivity in some sectors, the reallocation of labor across sectors helped prevent an even greater reduction of productivity in recent years.

The McMillan and Rodrik (2011) methodology is a good start to begin our investigation of the contribution of structural transformation to Latin America's growth experience. These authors separate aggregate productivity growth into structural factors (e.g., change in technology) and labor reallocation. The methodology consists of decomposing aggregate productivity according to

the following equation:

$$\Delta Y_t = \sum_{i=n} \Theta_{i,t-k} \Delta y_{i,t} + \sum_{i=n} y_{i,t} \Delta \Theta_{i,t}$$

where Y_t is the aggregate productivity, $y_{i,t}$ is the productivity in each sector of the economy and $\Theta_{i,t}$ is the sectorial share of employment.

The first term reflects productivity gains that resulted from changes in the technology within each sector, while the second term reflects the productivity gains that resulted from labor reallocation across sectors. Thus, the growth in labor productivity can be broken down into a more structural component (the first term in the equation) and a component associated with the process of structural transformation (the second term in the equation). Table 2 presents the breakdown of average growth in aggregate productivity for the nine Latin American countries under analysis.

Table 2: Breakdown of Productivity gains⁸(%, pp)

	1950-2005			1950-peak			peak-2005		
	Agreg	Tec	Str. Tr.	Agreg	Tecn	Str. Tr.	Agreg	Tecn	Str. Tr.
Brazil	2.3	1.6	0.7	4.7	2.6	2.1	-0.5	-0.7	0.2
Argentina	0.8	1.1	-0.2	1.7	1.3	0.4	0.1	0.5	-0.4
Chile	1.8	1.9	-0.1	1.2	1.1	0.0	2.9	2.9	0.0
Mexico	1.7	0.8	0.9	3.3	1.7	1.6	0.3	-0.2	0.5
Colombia	1.5	1.2	0.3	2.5	2.0	0.5	0.5	0.3	0.2
Venezuela	0.0	0.0	0.0	2.5	1.6	1.0	-1.3	-1.2	-0.2
Peru	1.1	0.7	0.3	3.8	2.4	1.4	-0.1	0.0	-0.1
Bolivia	0.9	0.4	0.5	—	—	—	—	—	—
Costa Rica	1.9	1.5	0.5	4.0	2.8	1.2	0.7	0.4	0.3

Results vary across countries and periods, but we can conclude that the reallocation of labor was an important source of productivity gains for all of the countries from 1950 to 2005. When considering the entire period in six economies, the contribution of structural transformation to aggregate growth was above 20%. In two of them, Mexico and Bolivia, more than half the observed growth was due to sector shifts. Not surprisingly, in Chile and Argentina where the process of structural transformation was well advanced, the impact was negligible and negative.

When we consider the period from the peak of relative productivity to 2005, the process of structural transformation prevented a more significant decline in labor productivity in some countries (e.g., Brazil, Mexico and Colombia), while in other economies the reallocation of labor contributed negatively to the aggregate productivity of the economy (e.g., Venezuela and Argentina).

⁸We do not calculate the productivity gains by sub-period for Bolivia because the relative productivity declined throughout the sample. We divided the sample into two sub-periods for Chile: 1950-1986, when relative productivity decreased, and 1986-2005, when there was an expansion of relative productivity.

In Mexico, half of the growth is explained by structural transformation, and in the most recent period structural transformation more than offset the decline in labor productivity arising from the negative contribution of sectorial technology growth.

In the case of Brazil, the dynamics of productivity changed greatly from 1950-2005. From 1950-1980, there was a strong reallocation of labor from agriculture to the fast-growing manufacturing and services sectors⁹. According to the methodology of McMillan and Rodrik (2011), labor reallocation explains almost half the aggregate growth during the period. As noted previously, productivity in services declined and the industrial sector's productivity slowed during the 1981-2005 period in Brazil. The gains arising from the continued decline in labor's share of the agricultural sector could not offset the sharp decline in productivity in services. The results in Table 4 show that without the process of structural transformation, aggregate labor productivity would have declined even more than it did in 2005 with respect to the peak year.

In Mexico, structural transformation was extremely important. Its contribution to aggregate productivity growth is approximately the same as that of within-sector technological change in the convergence period. This effect was not only because the difference in productivity level between agriculture and services and industry was very large during the period, but also because in both service sectors, productivity growth was significant. Hence, there was a relevant alone-time gain when a worker moved out of agriculture, but her productivity in the now larger service sector kept growing for many years. In the second period, the continuation of this process avoided a decline in aggregate productivity, as the contribution of technological change was negative. Peru is another country where structural transformation is an important factor in explaining aggregate growth.

The reallocation of labor across sectors in Argentina did not contribute as much to productivity growth in its two sub-periods as in Brazil, Mexico or Peru. The first period was characterized by a reduction in the share of employees in the less-productive sector of the economy (agriculture), an increase in the labor share in services and relative stability in the industrial sector, and this process explains one-fifth of Argentina's growth. From 1976-2005, there was a labor reallocation from agriculture and industry to services. Because labor productivity in the services sector was much lower than in the industrial sector, the loss of productivity arising from the reallocation of labor from manufacturing to services more than offset the gains arising from the reallocation of labor from agriculture to services. As a result, the contribution of the structural transformation process was negative. Likewise, growth in Chile did not benefit at all from labor reallocation across sectors; all productivity gains are explained by factors related to the higher efficiency of the economy as a whole.

The aggregate productivity in Venezuela grew by only 0.05% per year between 1950 and 2005. As in other Latin American countries, the most significant increase in productivity occurred in

⁹The percentage of workers employed in the industrial sector increased from 17% in 1950 to 23% in 1980, while the share of employment in the services sector increased from 20% to 39% during the same period.

the beginning of the period (in the case of Venezuela, from 1950-1970), and during this period structural transformation explains 39% of the productivity gains (1.0 percentage point). In the second sub-period, the aggregate productivity of the Venezuelan economy contracted at an annual rate of 1.3%, and all of the sectors contributed to the lower growth; in fact, the productivity of the sectors decreased at more or less the same rate. Thus, the large decline in Venezuela's relative productivity in the last thirty years can be explained by the inefficiency of its economy as a whole.

3 The Model

The decomposition exercise in the last subsection, and the other stylized facts presented previously, indicate that sector reallocation may be extremely important in explaining Latin America's growth experience. However, this partial equilibrium analysis does not consider several feedback effects that a richer environment may capture. In this section, we present a four-sector general equilibrium model, similar to Duarte and Restuccia (2005) and Rogerson (2005), to decompose and measure the contribution of each sector to the slowdown in labor productivity observed in the region. Here we breakdown the services sector in modern services and traditional services. We follow this approach as modern services are usually associated with higher productivity growth rates than the traditional sub-sectors.

The economy is populated by a representative household that lives for infinite periods. Time is discrete, and at each time t four items are produced: agricultural good (a), manufactured good (m), traditional services ($strad$) and modern services (sm). The production function is given by:

$$Y_i = A_i L_i,$$

for $i \in \{a, m, sm, strad\}$, where Y_i is the output in sector i , L_i is the labor allocated to the production sector i , and A_i is the technology employed in each sector i . The household has a unit time which is supplied inelastically, and the size of the population is normalized to 1.

The household preferences over consumption goods are represented by:

$$\sum_{t=0}^{\infty} \beta^t u(c_t, c_{at}),$$

where c_{at} is the consumption of the agricultural good at t and c_t is the consumption of a composite of industrial goods and services at the date t . The service good is also a composite of traditional services and modern services. The utility function is given by:

$$u(c_t, c_{at}) = \log(c_t) + V(c_{at}),$$

where $V(c_{at})$ is characterized by:

$$V(c_{at}) = \begin{cases} -\infty, & \text{when } c_a < \bar{a} \\ \min\{c_a, \bar{a}\}, & \text{when } c_a \geq \bar{a} \end{cases}$$

i.e., the household cares only about consuming the subsistence level of agricultural good. The composed good, c_t , is given by:

$$c_t = [bc_{m,t}^\rho + (1-b)(c_{s,t} + \bar{s})^\rho]^\frac{1}{\rho},$$

$$c_{s,t} = [\phi c_{strad,t}^\varepsilon + (1-\phi)c_{sm,t}^\varepsilon]^\frac{1}{\varepsilon}$$

where $\bar{s} > 0$, $b \in (0,1)$, $\phi \in (0,1)$, $\rho < 1$ and $\varepsilon < 1$. The parameter \bar{s} can be interpreted as the home production of services. The parameters ε and ρ are the substitution elasticities between the traditional service good and the modern service good, and the industry good and the composite service good, respectively, and they are very important for determining the speed of labor reallocation across sectors.

There is a continuum of firms in each sector, operating in perfect competition in the factor and production markets. The problem of the representative firm, at each date t , given prices and wages, is:

$$\max_{L_i \geq 0} p_i A_i L_i - w L_i, \quad (1)$$

where L_i is the demand for labor in sector i .

We can write the representative household problem for each date t as:

$$\max_{c_i \geq 0} \log \left[bc_m^\rho + (1-b) \left([\phi c_{strad,t}^\varepsilon + (1-\phi)c_{sm,t}^\varepsilon]^\frac{1}{\varepsilon} + \bar{s} \right)^\rho \right]^\frac{1}{\rho} + V(c_a) \quad (2)$$

s.t.

$$p_a c_a + p_m c_m + p_s c_{sm} + p_{strad} c_{strad} = w.$$

The market clearing conditions are:

1. Supply and demand for labor must be equal at each date t :

$$L_a + L_m + L_{sm} + L_{strad} = 1. \quad (3)$$

2. All production will be consumed in each of the four sectors:

$$c_a = Y_a, \quad c_m = Y_m, \quad c_{sm} = Y_{sm}, \quad c_{strad} = Y_{strad}. \quad (4)$$

3.1 Equilibrium

A competitive equilibrium for this economy is a set of prices $\{p_a, p_m, p_{sm}, p_{strad}\}$, consumption allocations $\{c_a, c_m, c_{sm}, c_{strad}\}$, and labor allocations $\{L_a, L_m, L_{sm}, L_{strad}\}$, such that:

1. Given prices $\{p_a, p_m, p_{sm}, p_{strad}\}$, the labor allocations for the firm $\{L_a, L_m, L_{sm}, L_{strad}\}$ solve (1).
2. Given prices $\{p_a, p_m, p_{sm}, p_{strad}\}$, the consumption allocations for the household $\{c_a, c_m, c_{sm}, c_{strad}\}$ solve (2).
3. Market Clearing: (3) and (4) must be satisfied.

Normalizing the wage at 1, we arrive at the following first order conditions for the firm's problem:

$$p_a = \frac{1}{A_a}; \quad p_m = \frac{1}{A_m}; \quad p_{sm} = \frac{1}{A_{sm}}; \quad p_{strad} = \frac{1}{A_{strad}}. \quad (5)$$

That is, for the four sectors of the economy, the price of each good is inversely related to the productivity of the sector.

To find the demands for the four goods, we must take the first order conditions of the household problem. First, note that by the definition of the function $V(c_a)$, we have that $c_a = \bar{a}$, i.e., the consumption of the agricultural good for the household will always be the subsistence level \bar{a} . Solving (2), and manipulating the first order conditions, we obtain the following equations for relative prices:

$$\frac{b}{(1-b)} \left(\frac{c_m}{[\phi c_{strad}^\varepsilon + (1-\phi) c_{sm}^\varepsilon]^{\frac{1}{\varepsilon}} + \bar{s}} \right)^{\rho-1} \frac{1}{[\phi c_{strad}^\varepsilon + (1-\phi) c_{sm}^\varepsilon]^{\frac{1}{\varepsilon}-1} \phi c_{strad}^{\varepsilon-1}} = \frac{p_m}{p_{strad}}, \quad (6)$$

$$\frac{b}{(1-b)} \left(\frac{c_m}{[\phi c_{strad}^\varepsilon + (1-\phi) c_{sm}^\varepsilon]^{\frac{1}{\varepsilon}} + \bar{s}} \right)^{\rho-1} \frac{1}{[\phi c_{strad}^\varepsilon + (1-\phi) c_{sm}^\varepsilon]^{\frac{1}{\varepsilon}-1} (1-\phi) c_{sm}^{\varepsilon-1}} = \frac{p_m}{p_{sm}} \quad (7)$$

and

$$\frac{\phi}{1-\phi} \left(\frac{c_{strad}}{c_{sm}} \right)^{\varepsilon-1} = \frac{p_{strad}}{p_{sm}}. \quad (8)$$

With equations (6), (7), (8), the market clearing conditions, and $L_a = \frac{\bar{a}}{A_a}$, we find L_{strad} , L_{sm} and L_m .

3.2 Calibration

In our strategy, we first calibrate a benchmark economy (in this case, the U.S.). We then use some of the preference parameters of this economy, in addition to equilibrium conditions of the model, and some targets to calibrate the Latin American economies.

We select values for the parameters b , ϕ , ρ , ε , \bar{a} and \bar{s} , as well as time series for the relative productivity in each sector, $A_{i,t}$, for $i \in \{a, m, sm, strad\}$, so that the model replicates the employment data in each sector over the period from 1950-2005. Using the equilibrium relationships of the model, we calculate the relative productivities in each sector of the Latin American economies in 1950¹⁰. In the following years, productivity grows at the rate of growth of the sectorial productivities observed in the data. Denoting α_i as the annualized growth rate of productivity in sector i , the path for productivity in the three sectors for the following years is $A_{i,t+1} = (1 + \alpha_i) A_{i,t}$, where α_i is given by $\alpha_i = \left(\frac{A_{i,05}}{A_{i,50}} \right)^{\frac{1}{55}} - 1$.

The parameter \bar{a} , which can be interpreted as the subsistence level of consumption of the agricultural product, is chosen to match the share of employment in agriculture in 1950. The value of \bar{s} is selected to match the employment share in manufacturing in 1950. Thus, given the values of b , ρ , ε and ϕ , we find \bar{s} . The parameters b and ρ were constrained to be compatible with the values found in the literature. For the parameter b , we selected the 0.02 value, in line with the value found in Rogerson (2005), while for the case of ρ , we constrained the value to be in the range from -1.5 to -2.67 , compatible with the values found in Duarte and Restuccia (2005) and Rogerson (2005). We chose -2.67 . With these constraints, the parameters ε , ϕ and ρ were chosen jointly to approximate the paths (from 1951 to 2005) of the labor share in manufacturing, modern services and traditional services generated by the model and those observed in the data.

Note that in the case of the U.S. economy, the calibration strategy does not require that the path of employment in manufacturing predicted by the model and the observed data be exactly the same. In the case of the Latin American economies, these series are, by construction, exactly the same¹¹.

The table below describes the values for each parameter and the variable used as a target in the calibration.

¹⁰The sectoral productivities for the U.S. economy are normalized to 1 in 1950 so that the sectoral productivities of the Latin American economies are measured relative to the U.S. economy.

¹¹For the Latin American economies, we follow the approach used by Duarte and Restuccia (2005), who added a time-varying wedge in non-market activities in the services sector in Portugal so that the model was able to exactly replicate the path of the employment share in manufacturing during the period. This wedge could represent an increased role of taxes and other regulations in the market economy.

Table 3: Parameters of the model

Parameter	Value	Target
$A_{i,50}$	1.0	Normalization
$\{A_{a,t}\}_{50}^{05}$	$\{.\}$	Productivity growth in agriculture
$\{A_{m,t}\}_{50}^{05}$	$\{.\}$	Productivity growth in industry
$\{A_{sm,t}\}_{50}^{05}$	$\{.\}$	Productivity growth in modern services
$\{A_{strad,t}\}_{50}^{05}$	$\{.\}$	Productivity growth in traditional services
\bar{a}	0.09	Employment in Agriculture in 1950
\bar{s}	1.13	Employment in Industry in 1950
b	0.02	Rogerson (2005)
ρ	-2.67	Employment in industry, mod. and trad. services from 1951 to 2005
ε	-0.4	Employment in industry, mod. and trad. services from 1951 to 2005
ϕ	0.83	Employment in industry, mod. and trad. services from 1951 to 2005

4 Results

The model satisfactorily replicates the process of structural transformation of the economies in the region, as shown in Figure 4.

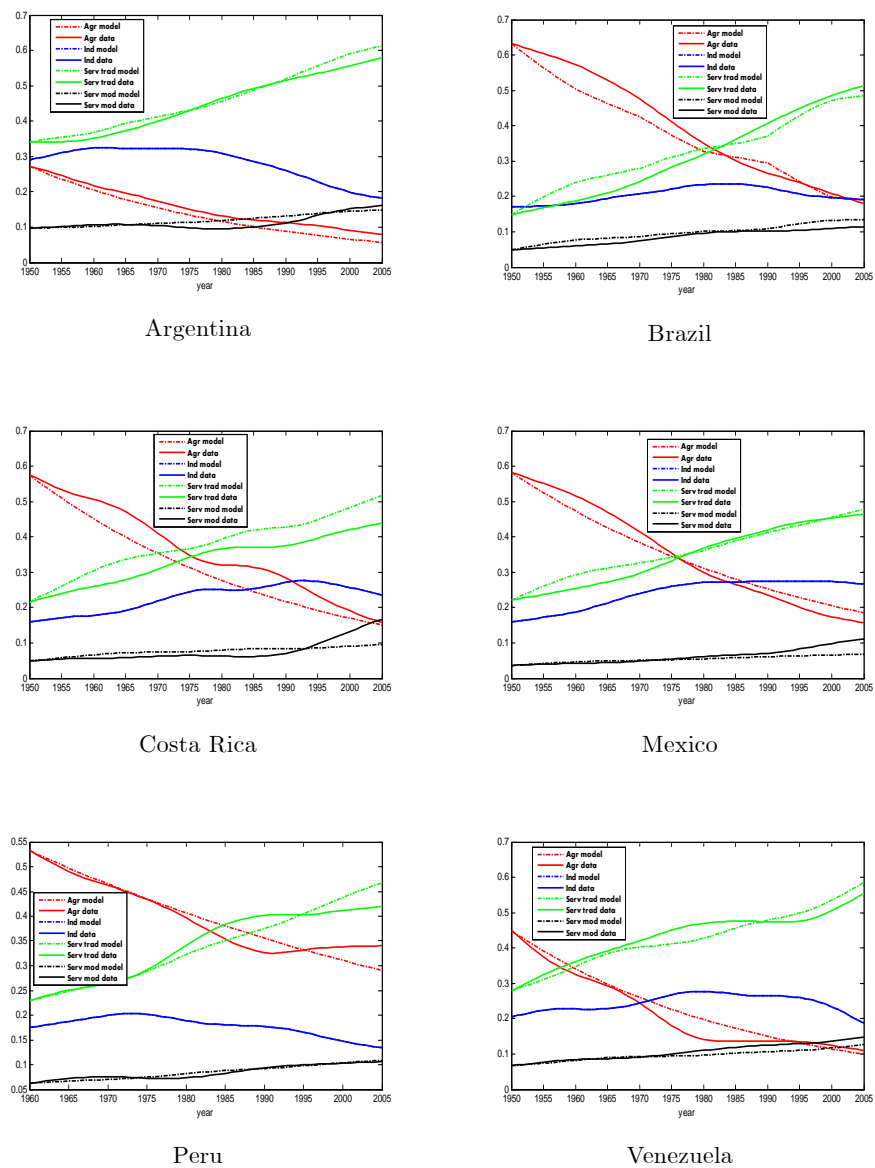


Figure 4: Employment share by sector - Model vs data

The model can replicate the trajectory of labor in all sectors of the economy. Specifically, the model is able to reproduce the sharp increase in the share of workers employed in traditional services in all economies of the region, the decrease in the percentage of employees in the agricultural sector and the slight increase in the share of workers in the modern service sector.

The model is also able to reproduce the path of aggregate productivity. Figure 5 displays the simulation for the Brazilian case ("Model") and the data ("Data (HP)"), which were filtered with the Hodrick-Prescott filter. As is clear from the picture, once we feed the sector productivities into the model simulation, we are able to reproduce the inverted U-shaped path of aggregate productivity in Brazil, matching the peak and the slopes very closely. In the next section, the model is used as a tool to decompose the productivity among sectors.

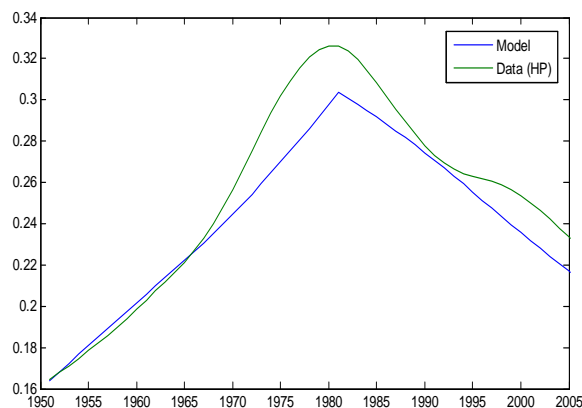


Figure 5: Relative productivity in Brazil

4.1 The Impact of Structural Transformation

In this section, we perform counterfactual experiments with the Latin American economies calibrated above. The goal is to quantify the impact of changes of sector composition on productivity. We focus on six economies that underwent a period of convergence of labor productivity and subsequently exhibited a decline in relative productivity.

In the first exercise, the sectorial productivities of all of the economies continue to grow at the same rates observed in their respective convergence period¹² during the second period. For example, we estimate what would have been the relative productivity for Brazil in 2005 if productivity in the four sectors between 1981 and 2005 had increased at the same rate as it increased from 1950-1980. This result - presented in the Benchmark column in Table 4 - is used as a reference for the other exercises.

¹²As a reminder, the convergence periods for each country are as follows: Argentina, 1950-1975; Brazil, 1950-1980; Mexico, 1950-1976; Costa Rica, 1950-1971; Venezuela, 1950-1970; and Peru, 1950 to 1974.

Table 4: Relative Productivity (w/ growth rates of the convergence period)

	1950	2005					
		Observed	Simulated				
			Benchmark	Agric.	Manuf.	Mod. Serv.	Trad. Serv.
Argentina	0.38	0.30	0.35	0.35	0.33	0.34	0.28
Brazil	0.16	0.23	0.48	0.50	0.39	0.37	0.34
Costa Rica	0.34	0.28	1.21	1.13	0.73	1.05	0.73
Mexico	0.40	0.38	0.88	0.85	0.73	0.72	0.72
Peru	0.27	0.21	0.51	0.52	0.47	0.42	0.30
Venezuela	0.55	0.28	0.83	0.77	0.66	0.71	0.53

The results suggest that the Brazilian economy - and all other economies examined - would have undergone a rapid process of convergence if it had maintained its productivity growth rates of 1950-1980 in the subsequent period. The relative productivity would have increased from 16% in 1950 to 48% in 2005, which is much higher than what was actually observed in 2005 (23%). Costa Rica would have surpassed the U.S., and Mexico and Venezuela would also have converged to output levels that were close to those of the leading economies of OECD.

There are general equilibrium factors at work here. The productivity gains are derived from the fact that productivity growth in services (modern and traditional) and industry remains high in the period from 1980-2005. Because productivity in the industrial sector grows relatively faster than in services, especially when compared to traditional services, there is a large shift of labor from manufacturing to services. Thus, it is essential that the productivity growth in services remains high; otherwise, the shift of labor from manufacturing to services would decrease Brazil's relative productivity. Hence, the economy would have grown faster not only because each sector is growing faster but also because labor reallocation would occur faster than observed, and labor would migrate to sectors in which absolute productivity would now be even higher.

In a second group of counterfactual exercises, productivity growth in three of the sectors (e.g., agriculture, industry and modern services) are kept constant and equal to those in the convergence period, and we change the productivity growth in the other sector (e.g., traditional services) to be the same as in the period of decline in relative productivity. Thus, this exercise is similar to the previous counterfactual, except that in one of the sectors the rate of productivity growth in the most recent years of the sample is changed to be equal to that observed in the data. Thus, we are now measuring the contribution of each sector to the decline in (aggregate) relative productivity¹³.

In all cases, the contribution of traditional services to the productivity slowdown is the highest, although in some countries, the slowdown of manufacture and/or modern services had a similar

¹³As before, in the initial subperiod - the convergence years - we keep the rates of productivity growth in each sector constant and equal to those observed in this period.

contribution. For example, relative productivity would fall from 48% to only 34% if Brazil's traditional services sector had grown at the observed rates in the second period, while the other sectors continued to grow at their rates during the convergence period. In the case of manufacturing, the drop is considerably smaller, to 39%. In Peru, the largest part of the productivity decline is also explained by the traditional services sector, similar to Argentina and Venezuela. In these three cases, labor productivity would remain very close to the benchmark simulation if the growth rate of manufacturing was changed to its growth rate in the previous period. The same effect is observed when the growth rate of modern services continued to growth at its rate during the convergence period. In most cases, the contribution of agriculture is negligible, either because its growth rate was similar in both periods (e.g., in Brazil) or because the relative size of the sector was already small (as in Argentina).

In this study, we identified two channels affecting aggregate productivity when the rate of growth in traditional services is changed by the rate observed in the period of productivity decline. There is a direct effect of a smaller growth rate of productivity and an indirect effect of labor reallocation. In the latter case, lower productivity growth in traditional services increases the labor share of the sector and consequently reduces the labor share in manufacturing and modern services, sectors in which absolute and relative productivity are the highest. Thus, the decline in relative aggregate productivity is even more intense.

Another way to understand the impact of the reallocation of labor to the traditional services, which showed smaller gains in productivity compared with the other sectors, would be to analyze the trajectory of the relative productivity of the Latin American economies if there had been no structural transformation in the second period. That is, what would have been the productivity dynamics if the share of workers in each sector had remained constant after the peak? In the case of Brazil, the relative productivity would have been 0.25 in 2005, higher than that implied by the model (0.21), when we allowed the growth rates of labor productivity in each sector to be equal to those observed in the data. The absence of labor reallocation to sectors with smaller productivity gains implies, obviously, that relative productivity is higher than when we allow for the reallocation of labor.

In this case, the exercise indicates that structural transformation negatively contributed to the evolution of relative productivity in the most recent period. Although the exercises are not directly comparable - in the case of the McMillan and Rodrik decomposition, we used absolute productivity - this simulation reinforces previous results that the productivity gains arising from the structural transformation were concentrated in the period of convergence. In the subsequent period, when there was a contraction in relative productivity, the reallocation of labor from agriculture to the other sectors of the economy did not prevent the drop in productivity caused by the decline in productivity in traditional services.

If our model had considered capital in the production function, sectorial productivity changes

would obviously imply a reallocation of capital among the sectors. This movement suggests that our model underestimates the reallocation of labor across sectors: the marginal productivity of capital would increase (decrease) when the TFP in, for example, traditional services increased (declined), attracting (expelling) capital to this sector and raising (reducing) the production of the sector even more.

4.2 Comparison to South Korea

Similarly to Latin America, South Korea experienced a rapid process of structural transformation in the second half of the last century. In 1965, almost 60% of South Korea's labor force worked in agriculture and less than 30% in services. Forty years later, the share of the labor force in agriculture was less than 10%, and the share in services was more than 60%. However, unlike Latin America, South Korea experienced rapid and continuous convergence to the productivity levels of the leading economies: from 1965 to 2005, labor productivity increased at an annual rate of 4.3%, and in the same period, its productivity relative to the U.S. went from 0.14 to 0.52. In addition to faster productivity growth in the manufacturing sector (at a rate of 5.9% per year), productivity in the services sector showed an upward trend during the entire 1965-2005 period, growing at 1.5% per year. In contrast, manufacturing and services grew in Brazil by 1.7% and -0.1%, respectively, during the same period.

It would be interesting to estimate what would be Latin America productivity performance had the structural transformation process in the region occurred under South Korean sectorial productivity rates. We perform this estimation by implementing four counterfactual simulations for the same six economies of Table 4. For each of these countries, we retain the productivity growth rate in the second period ("divergence") in three sectors as in the data, and we change the growth rate in the remaining sector to that of the corresponding sector in South Korea. Thus, in the "Agriculture" simulation in Table 5, the growth rates of manufacturing, modern services and traditional services are kept as observed in the data after the peak, but the growth rate of agriculture is changed to that of South Korea.

Table 5: Relative Productivity (Counterfactual with S. Korean growth rates)

	1950		2005			
		Observed	Simulated			
			Agriculture	Manufacture	Mod. Serv.	Trad. Serv
Argentina	0.40	0.32	0.27	0.33	0.29	0.35
Brazil	0.16	0.23	0.22	0.27	0.26	0.28
Costa Rica	0.34	0.28	0.51	0.66	0.52	0.62
Mexico	0.40	0.38	0.52	0.66	0.59	0.55
Peru	0.27	0.21	0.25	0.26	0.25	0.32
Venezuela	0.55	0.28	0.37	0.47	0.46	0.51

Despite substantial productivity growth in South Korea's manufacturing sector, the productivity gains are not as large as one might expect when we equate the rate of productivity growth in this sector in Brazil to that of South Korea. This result is due to the reallocation of labor from manufacturing to services, which grew at a negative rate of -1.7% in the period from 1981-2005, so the productivity gains obtained from higher productivity growth in the industrial sector are offset by lower productivity levels and growth in the services sectors. The relative productivity of the Brazilian economy would have increased to 22% in the case in which we equalize Brazil's agricultural productivity growth rate to South Korea's, to 27% in the case of manufacturing, to 26% in the case of modern services and to 28% for the counterfactual for traditional services. Thus, this counterfactual suggests that even with strong productivity growth in the industrial sector, the Brazilian economy would not be able to maintain the rapid productivity convergence because of the low efficiency of the tertiary sector. Because services experienced the largest increase in the working population during the period under study, a sharp increase in relative aggregate productivity would not occur without high productivity growth in services, mainly in the traditional one.

Similarly, for three other economies - Argentina, Peru and Venezuela - the isolated impact of traditional services is stronger than that of the other remaining sectors, reinforcing the results of the previous simulations. In the case of Venezuela, if the traditional services had grown in the second period at South Korean rates, the aggregate productivity would be almost twice as large as observed in the data.

In contrast, if the industrial sector in Mexico had grown at the same pace as that of South Korea, Mexico's relative productivity would have been 66% of the US's productivity, so Mexico would have almost converged to the productivity level of the leading economies. A similar result was obtained in the Costa Rica simulation. This significant increase in productivity on the counterfactual in which we changed the rate of productivity growth in the industry to be the same as in Korea compared to the benchmark scenario stems from the fact that the share of workers in industry in these countries (Mexico, Costa Rica and Venezuela) in the early period of divergence in productivity was higher

than in other countries. This allowed a less intense reduction in the percentage of workers in industry as a result of the higher productivity growth in industry in this counterfactual. Moreover, unlike Argentina, which also had a high percentage of workers in the industry in the early period of divergence in productivity, the productivity performance of the industry sector in these economies was very poor in the period of divergence, which increased the room for further convergence in productivity relative to the U.S. economy.

Figures 6 and 7 present the results of a final simulation.

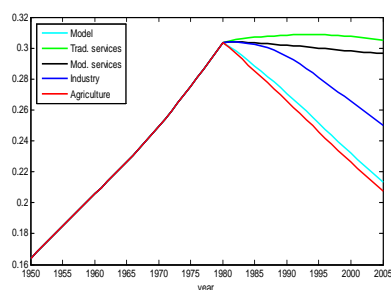


Figure 6: Relative productivity in Brazil

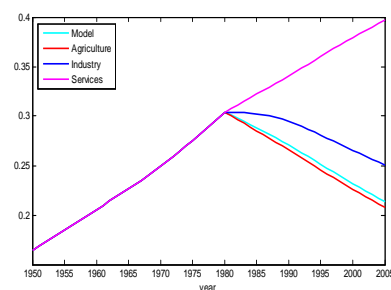


Figure 7: Relative productivity in Brazil

As in the exercises above with South Korean data, we kept the productivity growth rate of three sectors constant and equal to the observed data for the 1980-2005 period, and changed the growth rate in the remaining sector to that of the previous period, when Brazil was rapidly converging. We compared that result with the full simulation ("Model") when all of the sectors grew at the observed rates.

This exercise strengthens the results presented above. If productivity growth during the divergence period in traditional services was equal to that of the convergence period, aggregate productivity in Brazil would have increased to 31% of that of the U.S. in 2005, which is higher than the actual data and the full simulation. By changing the productivity growth rate in the industrial sector to the growth rate of the convergence period (and holding everything else constant), relative aggregate productivity would increase to just 25% of the U.S. productivity, while in the agriculture simulation, the trends are virtually the same. Moreover, if we consider the productivity growth rate during the divergence period in modern and traditional services equal to the growth rate in the convergence period, relative productivity in Brazil would be 40% of the U.S. productivity in 2005. Thus, this exercise reinforces the role of the services sector in driving the productivity path of the Latin America in recent decades.

This result contradicts recent proposals for implementing aggressive industrial policies in the region. In a general equilibrium environment, with reasonable assumptions on income elasticities of

demand, even when the rate of productivity growth in the industry is tripled the aggregate effect on the economy is limited. This is because there will be a shift of workers from manufacturing to services, where the level and productivity growth are low. In a partial equilibrium set up this is not taken into account and therefore the effect of higher industrial productivity in aggregate output is clearly overestimated.

5 Conclusion

This study analyzed the trajectory of aggregate productivity in Latin America during the period from 1950-2005. A common pattern in most economies examined was the increase in relative productivity during the early years of the sample - partly explained by structural transformation - followed by a strong reversal in subsequent years. In some countries, relative productivity in 2005 was lower than in 1950. In many cases, such as Brazil and Peru, the relative inefficiency of the services sector when compared with the developed nations - and the low growth rates of the sector in recent years - contributed significantly to the reversal of the productivity convergence.

Latin American economies are still in the process of reallocation of labor across sectors. The persistence of the inefficiency of services will likely hurt future growth in the region and prevent faster convergence of output levels - or any convergence at all - close to that of the leading nations. The sector of traditional services, usually characterized by low productivity and low productivity growth, has been the sector with the greatest increase in workers during the process of reallocation of labor that has taken place in Latin American economies over the past decades. The low dynamism of traditional services further inhibits the expansion of aggregate productivity of Latin American countries to levels close to those of the developed economies.

Despite the limitations imposed by the use of a fairly simple model of structural transformation, the main contribution of this work was identifying which sectors hastened or retarded the process of productive growth in Latin America. The next step is to examine the causes behind the inefficiency of the tertiary sector. A starting point may be the flow of low-skill labor from agriculture and industry to services, which has occurred in almost all Latin American countries. Thus, a model of structural transformation that incorporates human capital accumulation and occupational decisions would be a good first attempt to address this problem.

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