The structural transformation and aggregate productivity in Colombia

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Abstract

We document the process of structural transformation and aggregate productivity growth experienced by Colombia between 1956 and 2010. We analyze the quantitative role of sectorial labor productivity in accounting for these processes. We find that labor productivity growth by sector explains a significant part of labor shares behavior between sectors. We also observe that Colombia has lost competitiveness relative to the United States; this fact is explained by a lower productivity growth in all three sectors (agriculture, manufacturing and service) than in the US.

JEL Classification: O1, O4.
Keywords: Structural transformation, sectorial productivity.

1. INTRODUCTION

We analyze the long-run economic performance of Colombia and its relation to the process of structural transformation. In order to do this we follow closely the three-sector general-equilibrium model of Duarte and Restuccia (2007-2010). Between 1950 and 2010, Colombia increased its aggregate productivity gap with the United States from 30% to 20%. During the same period, the country experienced a process of structural transformation, whereby agricultural sector was replaced by the service sector. In this paper, we assess the quantitative role of sectorial productivity growth in accounting for the process of structural transformation in Colombia.

We first describe the behavior of aggregate productivity and we analyze its behavior by sectors. Then, we use the three-sector general-equilibrium model of the structural transformation developed by Duarte and Restuccia (2007-2010), we also use the same parameters for the benchmark economy (United States between 1956 and 2010). We first use the model to analyze the determinants of the process of structural transformation in Colombia; then we assess the role of sectorial labor productivity growth in the process of structural transformation and in aggregate productivity growth in Colombia.

We take four steps aimed at understanding the structural transformation in Colombia. First, we consider and economy equal to the benchmark economy in terms of preferences but featuring a lower initial level of economy-wide productivity, consistent with the observation that output per worker in Colombia was 30% of the US level in 1956. Second, we allow for relative productivity differences across sectors in 1956 that are consistent with the observed shares of employment in Colombia in this year. In these two exercises we consider that productivity growth across sectors is driven by the observations on sectorial productivity in Colombia. Finally, we consider time-varying rigidity to move out from agriculture to match the share of employment in services in Colombia.

We find that on the first exercise the model does not reproduce the behavior of labor shares in Colombia, in other words, when we reduce each sector's productivity to match 30% of labor

productivity in the US, when do not get a good adjustment of the model, in particular during the first year. However, when we allow the model to reproduce the initial labor shares it adjust pretty well to the data and reproduces the general tendency of labor shares by sectors in Colombia.

Finally, we analyze some counterfactuals in order to explain what would have happened to aggregate productivity in Colombia if conditions would have been different from those observed.

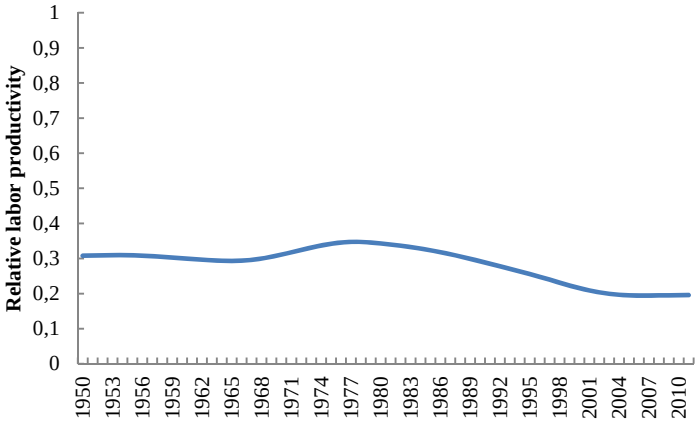
The paper is organized as follows. In the next section we document the long-run performance of the Colombian economy relative to the United States and the process of structural transformation in both economies. In Section 3, we describe the model; then in sections 4 and 5 we present the results. Finally, we conclude.

2. TRANSFORMATION AND LONG-RUN PERFORMANCE

2.1. The behavior of aggregate labor productivity.

We focus on labor productivity as a measure of economic performance. We find that between 1950 and 2010 Colombian workers lost competitiveness relative to the United States. However, this process was not constant among the whole period. In this sense, between 1950 and 1960 labor productivity in Colombia grew at the same rate as in the United States; after this period and almost during the whole decade of the 1970's Colombian workers gained competitiveness relative to the US. Finally, during the 1980's and 1990's relative labor productivity declined substantially (Figure 1).

Figure 1. Labor productivity in Colombia relative to the United States (Note: Labor productivity is GDP per worker from PWT8).



Source: World Penn Table 8.

Several facts help to explain the behavior of labor productivity in Colombia. First, during the 1970's most of Latin American countries experienced a decade of economic boom; in particular, external conditions were favorable to the region and allowed rapid economic growth. In this period, some countries increased their vulnerabilities to external conditions, since they expanded rapidly their external debt and their current account deficits. During the 1980's external conditions were not

favorable to the region and the vulnerabilities made evident: some countries experienced current account crises and regional economic growth decreased. These crises translated to lower productivity, and during this period most of the countries lost competitiveness relative to the US.

In the early 1990's Colombia started a process of commercial openness. During the first half of the decade, economic growth accelerated and employment levels increased. Unlike the 1980's, the lower productivity growth relative to the United States was experienced in a period of positive economic growth. In this sense, the decrease in competitiveness could be explained by informality and by higher levels of employment of individuals with lower productivity levels (this hypothesis is explored further in this document).

Finally, during the last years of the 1990's the country suffer a domestic crises, which began with the burst of a real estate bubble. The negative economic growth in these years explained the decrease in relative labor productivity in the country.

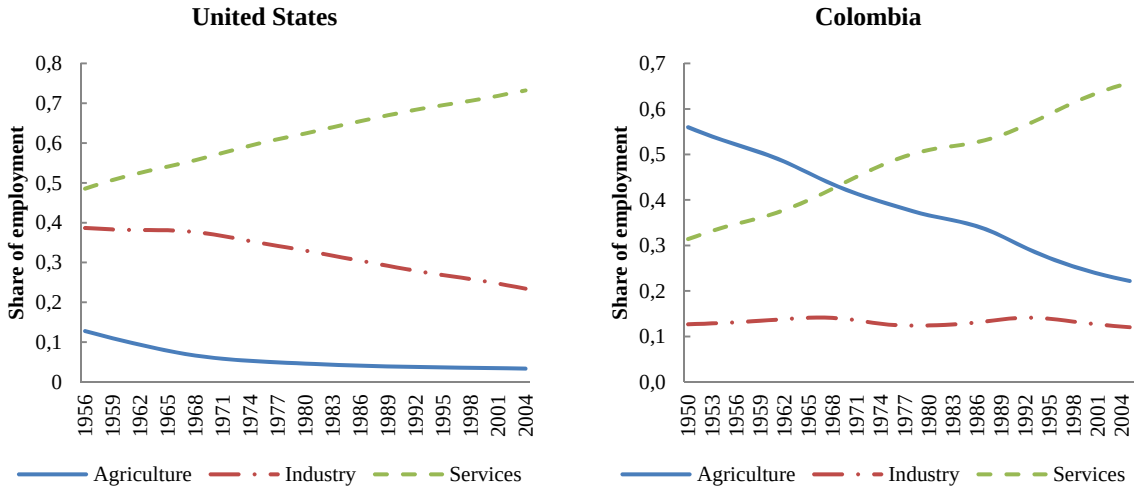
2.2. The process of structural transformation.

Differences in labor productivity levels between Colombia and the U.S can be explained by the process of structural transformation experienced in these countries.

In the United States, during the last decades the share of employment in agriculture and industry has declined, while in services it has gained participation. Given this behavior, actual employment in agriculture is fewer than the 5% of total employment. The change on employment structure has been engaged by a constant increase in labor productivity, especially in agriculture. In average, between 1956 and 2005 labor productivity in this sector increased 3.7% per year, while in industry and services it was 2.3% and 1.3%, respectively.

On the other hand, we find that Colombia has also experienced a process of structural transformation; however it has been different than in the United States. First, the share of employment in industry never reached the levels seen in the United States and it has been always been lower; furthermore, labor participation in this sector was relatively stable between 1956 and 2005. Given this, the biggest change in the shares of employment has occurred in agriculture and services. In spite of that, employment in agriculture is still high relative to the United States.

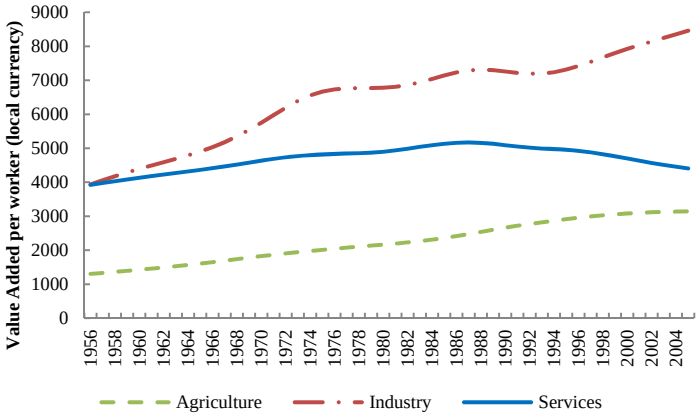
Figure 2. Share of employment by sector



Source: Groningen Growth and Development Centre (2005)

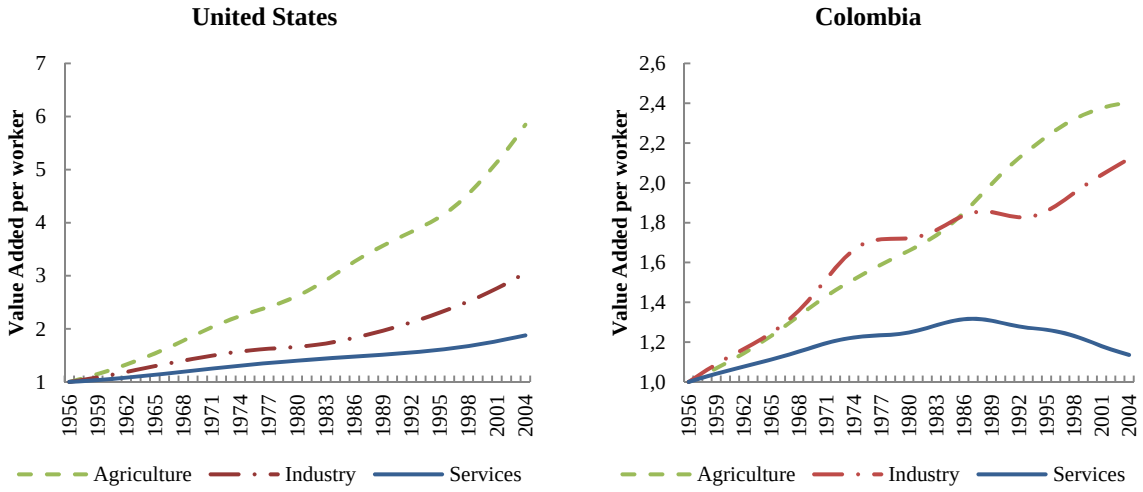
In terms of value added per worker, labor productivity in industry and services was similar in 1956, but during the last decades the gap between these two sectors increased substantially, because of the faster productivity growth in industry, and in particular for the decline in labor productivity observed in services since the early 1990's. Similar to the United States, agriculture in Colombia has been the sector whose productivity has increased faster in the last decades; however, compared to the productivity levels seen in services and industry, the value added per worker in this sector is still lower.

Figure 3. Labor productivity by sector - Colombia (local currency)



Source: Groningen Growth and Development Centre (2005)

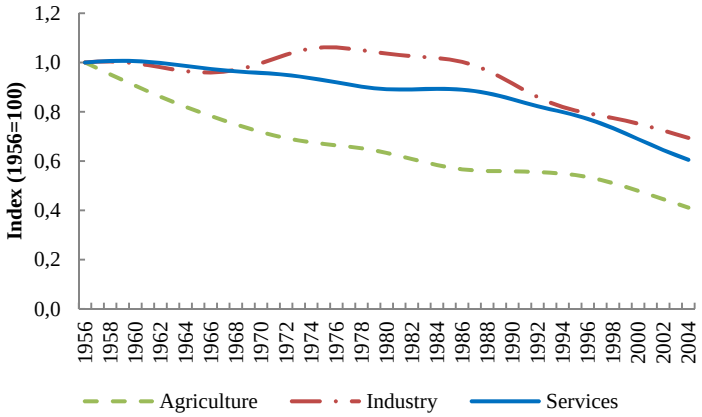
Figure 4. Labor productivity by sector (index 1956=100)



Source: Groningen Growth and Development Centre (2005)

Finally, relative to the United States, we find that labor productivity has declined in all three sectors, especially in agriculture. High protectionism policies implemented during the last decades, especially in favor of agriculture, could explain the competitiveness loss relative to the United States.

Figure 5. Relative labor productivity by sector (index 1956=100)



Source: Groningen Growth and Development Centre (2005)

2.3. What explains the bad behavior in the labor productivity of the services sector

In order to get a better perspective of labor productivity in services, we use the following division for the services sector and calculate the individual labor productivity and labor shares.

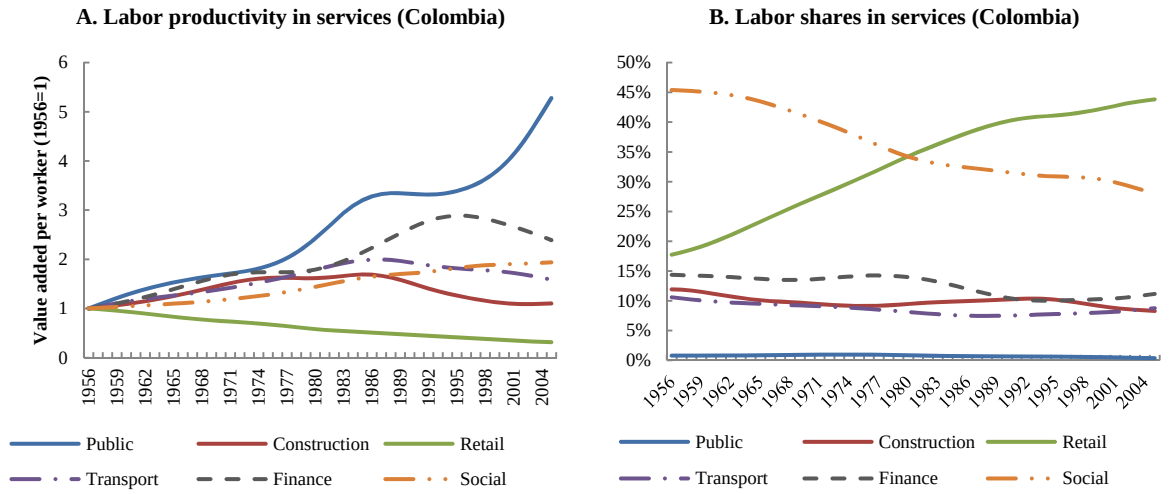
- Public utilities.
- Construction.
- Wholesale and retail trade, hotels and restaurants.

- Transport, storage and communication.
- Finance, insurance, and real Estate.
- Community, social and personal services, and Government.

We observe that some sub-sectors have experienced a positive behavior during the last decades; in particular labor productivity in public utilities has increased rapidly, with an average annual growth of 3.5%. Similarly, we find that labor productivity in finance, insurance and real estate services grew until the last years of 1990's; however, during the last decade it fell because of the crash experienced in that sub-sector. On the other hand, we see that labor productivity in transport and in trade has declined. For the case of wholesale and retail trade services we encounter that labor productivity in 2005 was 30% of it in 1956.

In relation to labor shares, we find that trade is the sub-sector whose participation has increased the most: in 1956 employment in trade services was 18% of the total employment generated by services sector, and in 2005 this same indicator was 43%. On the opposite side, we observe that labor shares in public utilities and community and social services have not increased in time; in fact, social services have constantly lost participation in employment generation. According to this, we can argue that the bad behavior of total labor productivity in services is partly explained by the negative tendency in labor productivity in wholesale and retail trade services.

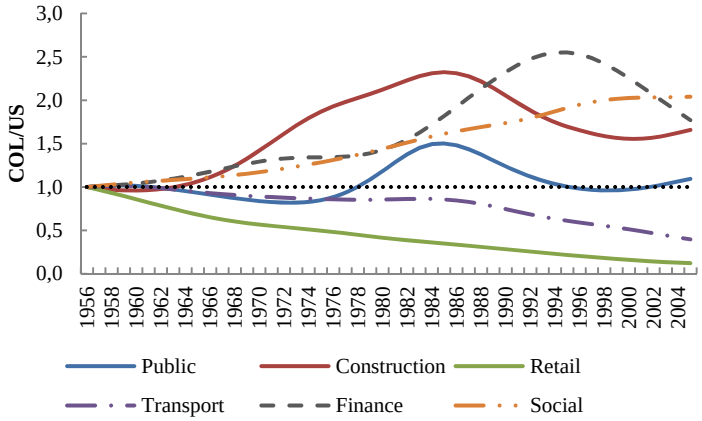
Figure 6. Labor productivity and labor shares in Services (Colombia)



Source: Groningen Growth and Development Centre (2005)

Relative to the United States we observe that workers in some sub-sectors have gained competitiveness in the last decades; this is truth for social and personal services, construction and finance. For the case of public utilities we find that labor productivity in Colombia and the United States has had a similar behavior, except during the 1980's when Colombian workers gained competitiveness relative to the U.S. Finally we see that for the complete period retail and transport are the sub-sectors whose labor productivity has declined relative to the US.

Figure 7. Labor productivity in services relative to the US (1956=1)



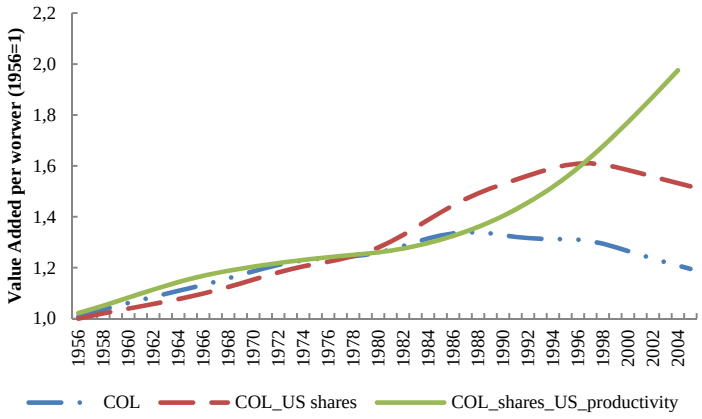
Source: Groningen Growth and Development Centre (2005)

2.3.1. ***Counterfactuals***

Given the productivity behavior in services sub-sectors we examine two counterfactuals for the Colombian economy. Under the first one we analyze *what would have happened to aggregate labor productivity in services in Colombia, if labor shares in that sector would have evolved as in the U.S.?*. The second counterfactual establishes *what would have happened to aggregate labor productivity in services if Colombian productivity in that sector would have evolved as in the U.S.?*

These two questions are represented in Figure 8. Under the first scenario we find that, different from reality, labor productivity in services would have increased between 1980 and 1998 and it would have started declining after 1998. Given this result we can argue that, for the Colombian economy after the 1980's, the observed decline in labor productivity (in services) is partly explained by changes in the labor shares. For the second counterfactual we find that in spite of labor shares productivity would have grown during the whole period; however it would have been lower than in the first scenario between 1980 and 1998.

Figure 8. Labor productivity in services - Colombia (1956=1)



Source: Groningen Growth and Development Centre (2005)

3. THE MODEL

We consider a simple model of structural transformation of a closed economy as in Duarte and Restuccia (2007). At each period, firms produce three kinds of goods: agriculture, manufacturing, and services. In the model, there are two sources of structural transformation: non-homothetic preferences and elasticity of substitution between consumption of service and manufacturing goods different from one.

3.1. Description of the economy

3.1.1. Production

At each period three goods are produced (agriculture (*a*), manufacturing (*m*), and services (*s*)) according to the following constant returns to scale production functions:

$$Y_i = A_i L_i, \;\; i \in \{a, m, s\} \qquad (1)$$

Where:

Table 1. Variables and parameters (Firms problem)

Variable	Description
$\boldsymbol{Y_i}$	Output in sector i.
$\boldsymbol{A_i}$	Labor input in sector i.
$\boldsymbol{L_i}$	Sector-specific technology parameter.

We assume that there is a continuum of homogeneous firms in each sector that are competitive in goods and factor markets. At each period the representative firm maximizes its benefits, given the output prices and wages:

$$\max_{L_i \geq 0} \{p_i A_i L_i - w L_i\} \qquad (2)$$

3.1.2. Households.

The economy is populated by an infinitely lived representative household of constant size, normalized to one. The household is endowed with *L* units of time each period, which are supplied inelastically to the market. The household has preferences over consumption goods as follows:

$$\sum_{t=0}^{\infty} \beta^t u\left(c_{a,t}, c_t\right), \; \beta \in (0,1) \qquad (3)$$

$$u\left(c_{a,t}, c_t\right) = a ln\left(c_{a,t} - \bar{a}\right) + (1-a) ln(c_t) \qquad (4)$$

$$c_t = \left[b c_{m,t}^{\rho} + (1-b)\left(c_{s,t} + \bar{s}\right)^{\rho}\right]^{1/\rho} \qquad (5)$$

Where:

Table 2. Variables and parameters (Household problem)

Variable or parameter	Description
$c_{a,t}$	Consumption of agricultural goods at time *t*.
c_t	Consumption of manufacturing ($c_{m,t}$) and service ($c_{s,t}$) goods at time *t*.
$\bar{a}$	Subsistence level of agricultural goods.
$\bar{s}$	Constant level of production of service goods at home.

We also consider that $\bar{s} > 0$, $b \in (0,1)$, and $\rho < 1$.These preferences establish that the income elasticity of consumption of service goods is greater than one. The parameter $\bar{s}$ can be interpreted as a constant level of production service goods at home.

According to the household's structure its problem is a sequence of static optimizations. At each period and given prices, the household chooses consumption of each good to maximize its utility subject to the budget constraint. Formally,

$$\max_{c_i \geq 0} \left\{ a ln\left(c_{a,t} - \bar{a}\right) + \frac{(1-a)}{\rho} ln\left(\left[b c_{m,t}^{\rho} + (1-b)\left(c_{s,t} + \bar{s}\right)^{\rho}\right]\right)\right\} \quad (6)$$

Subject to

$$p_a c_a + p_m c_m + p_s c_s = wL \quad (7)$$

3.1.3. Market clearing.

The total demand for labor must equal the exogenous supply of labor, in other words it must be true that:

$$L_a + L_m + L_s = L \quad (8)$$

Notice that, labor inputs in the model are associated with labor shares in the data. On the other hand, consumption of each good must equal its production:

$$c_a = Y_a;\ c_m = Y_m;\ c_s = Y_s \quad (9)$$

3.2. Equilibrium.

A *competitive equilibrium* is a set of prices $\{p_a, p_m, p_s\}$, allocations $\{c_a, c_m, c_s\}$ for the household, and allocations $\{L_a, L_m, L_s\}$ for the firms such that given prices:

- Firm's allocations solve its problem.
- Household's allocations solve its problem.
- Markets clear.

The first-order conditions from the firm's problem establish that the marginal benefit of a unit labor of cost must equal its marginal cost. Normalizing the wage rate to one, this condition implies that prices depends inversely on productivity:

$$p_i = \frac{1}{A_i} \tag{10}$$

Similarly, from the first-order condition for consumption we find that the labor input in agriculture is given by:

$$L_a = (1-a)\frac{\bar{a}}{A_a} + a\left(L + \frac{\bar{s}}{A_s}\right) \tag{11}$$

This equation implies that when labor productivity in agriculture increases, labor moves away from this sector.

Finally, using the market clearing conditions for output in manufacturing and services for labor we obtain:

$$L_m = \frac{(L-L_a)+\bar{s}/A_s}{1+x} \tag{12}$$

Where

$$x = \left(\frac{b}{1-b}\right)^{1/(\rho-1)}\left(\frac{A_m}{A_s}\right)^{\rho/(\rho-1)} \tag{13}$$

Notice that the relative allocation of labor between agriculture and services depends on their relative productivities and the services produced at home. Given this, we find that more productive sectors employ fewer workers.

4. CALIBRATION

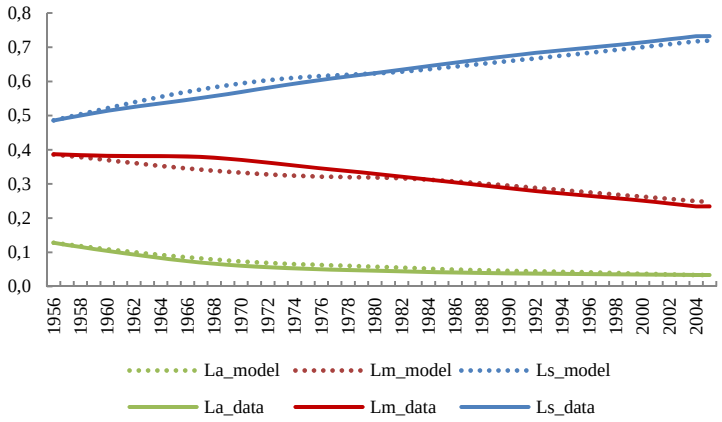
For the benchmark economy we use the parameters calibrated by Duarte and Restuccia (2010) for the US data for the period from 1956 to 1995 and we check that our results are similar to what they found. In this sense, we observe that the simple framework closely reproduces that features of the structural transformation of the United States during this period (Figure 9); in other words we find that given the productivity behavior in each year, the implied labor shares from the model are similar to the one observed in the data[1].

[1] For a detail explanation, see Duarte and Restuccia (2010).

Table 3. Parameter values and U.S. data targets.

Parameter	Value	Target
$A_{i,1956}$	1.0	Normalization.
$\{A_{a,t}\}_{t=1956}^{2005}$	{.}	Productivity growth in agriculture.
$\{A_{m,t}\}_{t=1956}^{2005}$	{.}	Productivity growth in industry.
$\{A_{s,t}\}_{t=1956}^{2005}$	{.}	Productivity growth in services.
a	0.01	Long-run share of hours in agriculture.
$\bar{a}$	0.11	Share of hours in agriculture in 1956.
$\bar{s}$	0.89	Share of hours in industry in 1956.
b	0.04	Share of hours in industry 1957-2004.
ρ	-1.5	Aggregate productivity growth.

Figure 9. Employment shares by sector – US



5. QUANTITATIVE ANALYSIS

5.1. The structural transformation in Colombia

We take four steps aimed at understanding the structural transformation in Colombia. First, we consider and economy equal to the benchmark economy in terms of preferences but featuring a lower initial level of economy-wide productivity, consistent with the observation that output per worker in Colombia was 30% of the US level in 1956. Second, we allow for relative productivity differences across sectors in 1956 that are consistent with the observed shares of employment in Colombia in this year. In these two exercises we consider that productivity growth across sectors is driven by the observations on sectorial productivity in Colombia. Finally, we consider time-varying rigidity to move out from agriculture to match the share of employment in services in Colombia. In all these experiments, the parameter value for $\bar{s}$ is adjusted to the initial value of labor share in services in Colombia.

5.1.1. Economy-wide productivity

The first exercise consists on reducing labor productivity in every sector in 1956 by a constant factor. As documented in Section 2, GDP per worker in Colombia in 1956 was 30% of GDP per

worker in the United States. Hence, this experiment considers that relative labor productivity in each sector was 30%, i.e., $A_{i,56} = 0.3$ for $i \in \{a, m, s\}$. For 1956 the model implies a share of employment in agriculture of 38% (52% in the data), a share of employment in services of 25% (35% in the data), and a share of employment in industry of 38% (13% in the data). The results of this exercise in terms of the shares of employment are reported in Panel A of Figure 10 where the solid lines represent the data and the dashed lines the model. Hence, relative to the data in 1956, the model implies too little employment in agriculture and services and too much in manufacturing. These results suggest that Colombia may be less than 30% productive in agriculture and more than 30% productive in manufacturing relative to the United States. We pursue this possibility in the next experiment.

5.1.2. Relative sectoral productivity in 1956 and sectoral productivity growth

In the second exercise, we calibrate sectoral productivity in 1956 to match the shares of employment across sectors in Colombia for the same year (furthermore to the relative aggregate productivity of 30%). Our calibration of this exercise implies that agriculture, manufacturing and services must be 22, 83 and 20 % as the benchmark economy in 1956. The results of this exercise in terms of the shares of employment are plotted in Panel B of Figure 10.

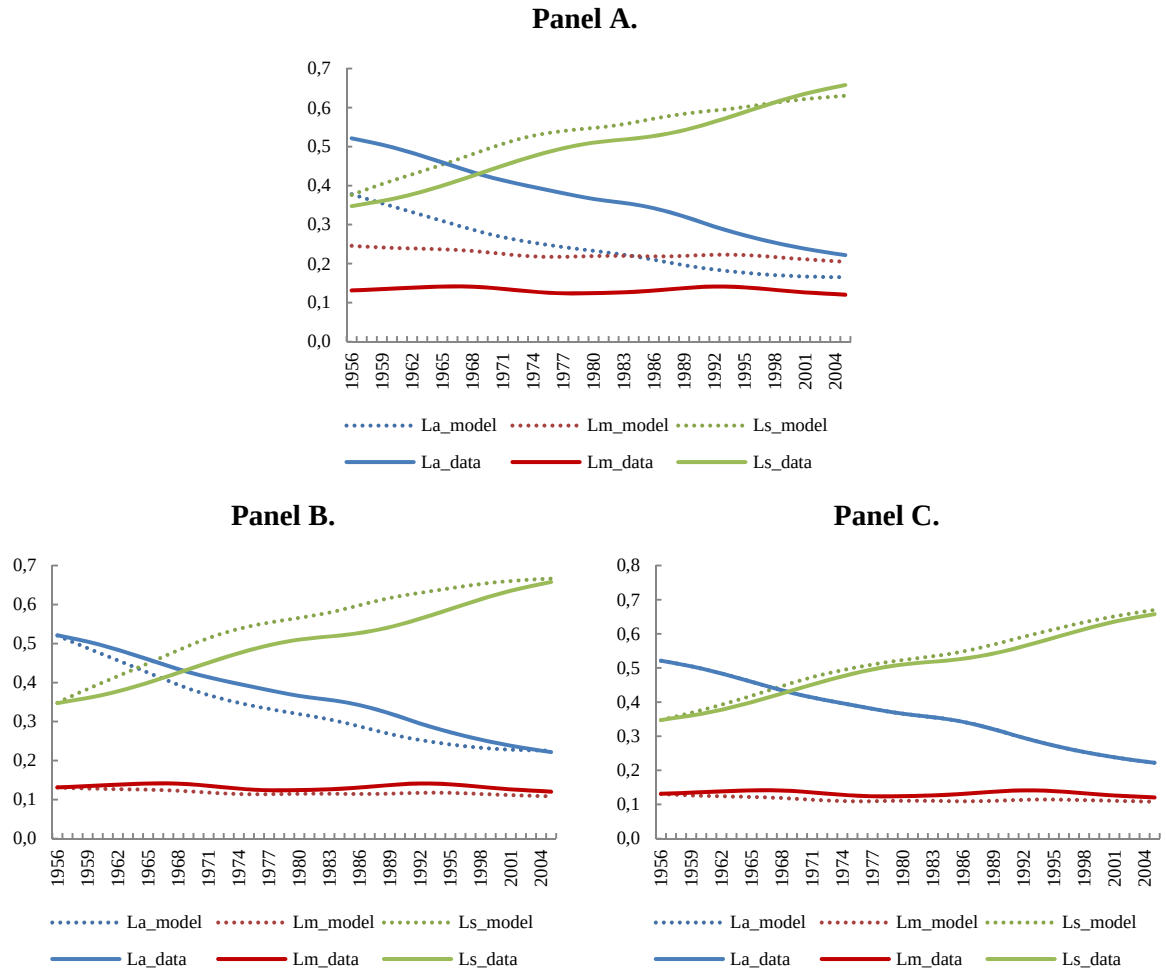
Notice that the model closely reproduces the behavior of labor shares in the manufacturing sector. In this sense, the model specification, in terms of preferences and production, is a good approximation to the manufacturing behavior. Furthermore, we observe that the model reproduces the global tendency of labor shares in Colombia; however, there are some features of agriculture and services that it is not capturing.

In particular, we find that during many years the implied labor shares in agriculture are lower than in the data; in other words, the characterization of preferences for agricultural goods in the model is not a perfect abstraction of the forces for employment in agriculture relative to the data. This result suggests that we need to modify some assumptions in the model in order to reproduce better agriculture and services behavior. Before we do this is important to notice some features of the Colombian economy and especially of its policy design.

During the analyzed period, different Governments designed policies in favor of the agricultural sector. Protectionism policies and high subsidies to the sector limited competition and created a rigidity to move out from agriculture. These policies affected other sectors in the economy, especially manufacturing, since firms were forced to use national agricultural inputs instead of imported ones. This fact limited productivity growth in industry and reduced the country's industrialization.

Given this rigidities we decide to force the model to reproduce Colombian employment shares for the whole period and for the other sectors we allow them to behave according to their productivity levels. Under this scenario we find a good representation of the Colombian economy. See Panel C in Figure 10.

Figure 10. Employment shares by sector – Colombia



5.2. Counterfactuals

Finally we analyze the behavior of Colombian labor shares and sectoral productivities for two alternative scenarios. In the first one, we calibrate the economy to reproduce initial conditions in Colombia, as in exercise two, but we assume that sectoral productivities behave as in the United States. In the second scenario, we use this initial conditions and parameters as in scenario 1 but we consider that sectoral productivities in each sector grow at its maximum observed level (in Colombia) between 1956 and 2005.

According to the results, we find that in both cases implied labor shares in agriculture (services) are lower (higher) than in the data; for the case of industry, scenario 1 is similar to the data while scenario 2 gives a lower labor share. In addition, for scenario 2 we observe that in Colombia the maximum productivity growth in services is similar to the average growth in the United States; for industry, it is higher and for agriculture it is lower. Given this, under scenario 2, the country gains competitiveness relative to the United States in industry and loses it in agriculture.

Table 4. Counterfactuals

	Share of employment (2005)			Productivity growth 1956-2005		
	Agr	**Indu**	**Serv**	**Agr**	**Indu**	**Serv**
Data	22.2%	12.0%	65.8%	1.81%	1.58%	0.24%
Model (2)	22.8%	9.9%	67.3%	1.81%	1.58%	0.24%
Scenario (1)	12.68%	9.01%	78.31%	3.70%	2.34%	1.27%
Scenario (2)	15.31%	5.68%	79.01%	2.67%	3.87%	1.42%

6. CONCLUSIONS

From 1950 to 2010, GDP per worker in Colombia relative to the United States decreased from 0.3 to 0.2. This increase on aggregate productivity gap with the United States was associated with a process of labor reallocation across sectors of production (agriculture, manufacturing and services) and with a lower labor productivity growth in all of them. We observe that labor productivity, relative to the United States has declined in all three sectors, especially in agriculture. High protectionism policies implemented during the last decades could help to explain this behavior. When we analyze some counterfactuals, we find that if labor mobility in services would have been different, the competitiveness loss relative to the U.S would have been lower.

We also analyze the quantitative role of sectorial labor productivity in accounting for the process of structural transformation. In order to do it, we use the model built by Duarte and Restuccia (2007-2010) and we adapt it to the Colombian economy. We find that labor productivity growth by sector explains a significant part of labor shares behavior between sectors. When we consider that labor productivity in each sector is reduced by a constant factor, similar to the one observed in relative aggregate productivity, the model implies too little employment in agriculture and services and too much in manufacturing; in other words, relative productivity in each sector is different than relative aggregate productivity. When we adjust for this the model reproduces the general tendencies of the data.

REFERENCES

Duarte and Restuccia (2007). "The structural transformation and aggregate productivity in Portugal," *Portuguese Economic Journal* 6(1): 23-46.

Duarte and Restuccia (2010). "The Role of Structural Transformation in Aggregate Productivity," *Quarterly Journal of Economics* 125: 129-73

Feenstra, Robert C., Robert Inklaar and Marcel P. Timmer (2013), "The Next Generation of the Penn World Table" available for download at www.ggdc.net/pwt

Groningen Growth and Development Centre 10-sector database, June 2007, http://www.ggdc.net/