The Role of Agricultural and Non-Agricultural Productivity in Latin American Development

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Abstract

We calibrate a simple neoclassical model of structural transformation for Chile, Brazil, Colombia, Ecuador, Peru, Paraguay and Bolivia. We show that slow growth in agricultural productivity can substantially delay the development process and result in significant differences in per capita incomes. The development process can be accelerated, however, by increasing productivity in the non-agricultural sector. In fact, in the long run, it is non-agricultural productivity what determines convergence. In our various exercises we find that...

Key words: Economic Development, Latin America, Agriculture Productivity, Manufacturing Productivity

JEL Classification: O47, O57, E13

1 Introduction

According to Lucas (2000), one of the fundamental reasons for the large income disparities observed between poor and rich countries is that the former started the process of industrialization much later than the latter. On this line of thought, Gollin, Parente, and Rogerson (2002) (henceforth GPR (2002)) suggest that countries begin the process of industrialization only after they are able to satisfy their basic agricultural (food) needs. According to these authors,

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therefore, improvements in agricultural productivity are key determinants of development as they allow countries to reach their basic agricultural needs sooner and begin to free up resources for the process of industrialization. On the contrary, countries experiencing low agricultural productivity levels would tend to lag behind.

In this paper we evaluate the potential of the GPR (2002) model in explaining the observed patterns of development in a sample of seven Latin American countries including Chile, Brazil, Colombia, Ecuador, Peru, Paraguay, and Bolivia. Studying a group of countries sharing similar colonial institutions and culture allows us to better evaluate the proposed channels of development described by the model. We find that our calibrated version of the GPR (2002) model generates paths of development that fit the observed data. Our exercise clearly illustrates that, while differences in agricultural productivity determine the extent of income differences during the first number of periods, it is non-agricultural productivity what determines the speed of convergence. We choose Chile as our benchmark economy. According to our data, Chile started to industrialize much earlier than the other countries in our sample. Not surprisingly, therefore, In recent periods, Chile’s income per capita has been 40 to 80 percent higher than the corresponding figure in the other countries.

The importance of agriculture for the industrialization process has been long noted in the development literature as in Johnston and Mellor (1961), Johnston and Kilby (1975) and Timmer (1988, 2002). Before industrialization, almost all the labor force worked in agriculture. Once agricultural productivity rises enough to allow the production of subsistence level of food, then labor moves out of the agricultural sector and into the non-agricultural sector. Hence, the agricultural sector as a share of the economy and the labor force starts falling.

The model by GPR (2002) can be considered an extension of Laitner’s (2000) and Hansen and Prescott’s (2002). The literature on this topic also includes, Caselli and Coleman (2001), who study the role of human capital accumulation as a factor that contributes to how quickly labor can move out of agriculture. Also, in a follow up paper, GPR (2007) use a similar model to account for a feedback effect from the manufacturing sector to agriculture. In a recent paper, Restuccia, Yang and Zhu (2008) also find that agricultural productivity is important for structural transformation, but that barriers to the adoption of agricultural technology explain the differences in both agricultural and overall productivity among countries. These studies are part of a broader branch of the literature studying agriculture in growth frameworks; for example, Echeverria (1997), Kongsamut et al. (2001), Glomm (1992), and Lucas (2004).

As we mentioned before, our findings indicate that the model provides an adequate description of the observed income disparities of the seven Latin
American countries in our sample. Low agricultural productivity delays the beginning of the process industrialization, in some cases - like Paraguay and Bolivia -, by about 100 years compared to the leader of the group, Chile. We also find that the reduction in income differences (convergence) depends critically on productivity in the non-agricultural sector. Improvements in non-agricultural productivity between 20 and 100 percent would be required to significantly close the income gap with Chile by the end of the century.

The paper proceeds as follows. Section 2 describes the model. Section 3 presents the calibration and quantitative evaluation. Section 4 concludes.

2 The Model

The basic structure of the GPR (2002) model is that of the one sector neoclassical growth model extended to include an explicit agricultural sector. In this framework, development is associated with industrialization. Industrialization happens only when the country experiences a structural transformation (namely an improvement on agricultural productivity) that withdraws employment from the agricultural sector and moves it into the non-agricultural sector. Asymptotically, agriculture’s employment share shrinks to zero and the model becomes identical to the standard one-sector neoclassical growth model. We present here the basic features of the model.

2.1 Representative household

The economy is inhabited by an infinitely-lived household, endowed with a unit of time in each period, who maximizes lifetime utility as given by:

\[
\sum_{t=0}^{\infty} \beta^t U(c_t, a_t)
\]

where \( c_t \) is the non-agricultural good and \( a_t \) is the agricultural good.

GPR (2002) adopt a Stone-Geary variety for the functional form of the utility function in order to generate a structural transformation.

\[
U(c_t, a_t) = \begin{cases} 
\log(c_t) + \bar{\alpha} & \text{if } a_t \geq \bar{\alpha} \\
\bar{\alpha} & \text{if } a_t < \bar{\alpha}
\end{cases}
\]
This extreme functional form allows the economy to withdraw labor from the agricultural sector once (per capita) output in this sector reaches the subsistence level of $\pi$. There is nothing particularly special about the value of $\pi$ and the results are not be much affected if it was either somewhat higher or lower.  

2.2 Nonagricultural sector

GPR (2002) correctly called one of the sectors of this economy the “non-agricultural” sector, since it includes not only manufacturing but also services, industrial agriculture, and everything else. This sector produces output ($Y_{mt}$) by combining capital ($K_{mt}$) and labor ($N_{mt}$) using the following function:

$$Y_{mt} = A_m \left[ K_{mt}^\theta ((1 + \gamma_m) N_{mt})^{1-\theta} + \alpha N_{mt} \right]$$

where $A_m$ (TFP) is assumed country-specific and determined by policies and institutions. The rate of exogenous technological change ($\gamma_m$) and the (small) number $\alpha$ are assumed identical across countries. Since developing countries are generally not in the business of creating ideas, the assumption of exogenous technological change is reasonable from their perspective.

The law of motion for the stock of capital is standard:

$$K_{mt+1} = (1 - \delta)K_{mt} + X_{mt}$$

where $\delta$ is the depreciation rate and $X_{mt}$ is investment. In fact, output from the non-agricultural sector can be used for consumption or investment.

2.3 Agricultural sector

The agricultural sector produces output ($Y_{at}$) using only labor ($N_{at}$). There are two available technologies for producing the agricultural good: a traditional and a modern one.

In the traditional technology, one unit of time produces $\pi$ units of the agricultural good. GPR (2002) point out that there are theoretical reasons to believe...
that a value close to $\pi$ is appropriate. Models with endogenous fertility, for example, suggest that output per capita will be close to subsistence levels for economies that have not begun the process of industrialization.\(^4\)

On the other hand, the modern agricultural technology is subject to exogenous technological change:

$$Y_{at} = A_a(1 + \gamma_a)^t N_{at}$$  \hspace{1cm} (5)

where $A_a$ (TFP) is assumed country-specific and determined by policies and institutions. It is also affected by climate conditions and the quantity and quality of land per person. Technological innovations that are useful for a specific crop in a given climate may not be particularly relevant for other crops in other parts of the world. This effect may generate large differences in cross-country productivity levels that are independent of policy.

GPR (2002) assume that the rate of exogenous technological change, $\gamma_a$, is common across countries and output from this sector is only used for consumption. Therefore, the agriculture resource constraint is simply:

$$a_t \leq Y_{at}$$  \hspace{1cm} (6)

It is important to mention that the agricultural sector is a “basic” agricultural sector in the sense that its output only satisfy “basic needs.” So, this agricultural sector needs to be clearly differentiated from industrial agriculture or agriculture for export.

2.4 The competitive equilibrium

Here we briefly describe the competitive equilibrium of this economy by focusing on how different values of agricultural TFP ($A_a$) affect the resulting dynamic allocations. The competitive equilibrium involves two steps:

1. At the beginning labor is allocated entirely to agriculture until:

$$A_a(1 + \gamma_a)^t \geq \bar{a}$$

Once this is satisfied, agricultural production switches to the modern technology and labor starts to flow out of agriculture at the rate $\gamma_a$.

Hence:

\[ N_{at} = \min \left\{ \frac{a}{A_a(1 + \gamma_a)^t}, 1 \right\} \]

and

\[ N_{mt} = 1 - N_{at} \]

(2) Given the time path of labor allocations, the optimal path of investment is found by solving the households’ optimization problem. Households choose consumption of the non-agricultural good and capital to maximize the utility function (1) subject to the feasibility constraint:

\[ c_t + X_{mt} = Y_{mt} \]

and the law of motion of capital (equation 4).\(^5\)

The Euler equation for this optimization problem is:

\[
\frac{A_m[K_{m,t+1}^\theta((1 + \gamma m)^{t+1}N_{m,t+1})^{1-\theta} + \alpha N_{m,t+1}]}{\beta A_m[K_m^\theta((1 + \gamma m)^{t}N_m)^{1-\theta} + \alpha N_m]} - K_{m,t+2} + (1 - \delta)K_{m,t+1}
= \frac{A_mK_{m,t+1}^\theta - \theta((1 + \gamma m)^{t+1}N_{m,t+1})^{1-\theta} + 1 - \delta}{1 - \theta}
\]

and the steady state capital level is:

\[
K_{m,ss} = \left[ \frac{(1/\beta - 1 + \delta)}{(A_m)^\theta((1 + \gamma m)^{ss}N_{m,ss})^{1-\theta}} \right]^{1/(\theta - 1)} \tag{7}
\]

This is equivalent to solving the transitional dynamics of the neoclassical growth model with an exogenous time profile of labor input given by \( N_{mt} \). As technology in the agriculture sector increases at rate \( \gamma_a \), \( N_{at} \) eventually approaches 0, and \( N_{mt} \) approaches 1. Asymptotically, therefore, the model is identical to the standard one-sector neoclassical growth model.

3 Empirical Exercises

In this section we show that differences in agricultural and non-agricultural productivity explain the observed differences in incomes per-capita in our sample of seven Latin American countries. We perform some numerical simulations to show the usefulness of the model in providing quantitative analysis and policy implications.

Before describing the data and the calibration, it is important to show the evolution of GDP per capita for the countries in our sample. Our data ranges from 1900 to 2000.\(^5\) and the appropriate nonnegativity constraints and constraints on \( K_{mt} \).
As one can clearly see in Figure 1, Chile has been above the rest of the countries since the early years of the century. This difference, in fact, has expanded in recent years challenging the notion of absolute convergence, which is the definition of coverage that we employ in this paper. Partially because of this observation and partially because of data availability, we make Chile our benchmark economy.

There is no consensus about convergence in Latin American countries and only few studies have analyzed it. According to Barrientos (2011) these studies all differ in their samples, periods, and methodologies which makes it very difficult for comparative purposes. In addition, Barrientos (2011) argues that almost none of the studies she found relates economic history to convergence. One obvious reason could be the lack of data. Most of the studies start their analysis from around 1960.

Figure 2 shows the contribution of the agricultural and manufacturing sectors to GDP per capita for the countries in our sample. As mentioned above, a key implication of GPR’s (2002) model is that countries end up producing the same level of agricultural output per-capita and income differences in the long run come exclusively from the non-agricultural sector. Using the manufacturing sector as a proxy for an overall non-agricultural sector, Figure 2 shows that,

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6 As it is well known, absolute-\( \beta \) or catching-up convergence happens when a number of economies converge to one another in the long run, independently of their initial conditions. Other definitions of convergence include: Conditional-\( \beta \) convergence, club convergence and \( \sigma \)-convergence. For an extensive discussion of these concepts see Galor (1996).
indeed, in Latin America, most of the bulk of the difference between Chile and the rest of the countries comes from the latter sector.

Fig. 2. Agriculture and manufacturing value added

3.1 Data

As mentioned above, finding historical data for Latin American countries is not an easy task. Fortunately, in our case, the data requirements are relatively small. The main variable needed is the labor share in agriculture ($N_a$). Data for this variable has been collected from Banks, for the early periods, and from the Food and Agriculture Organization (FAO) for the last periods. For Chile, we also use the data set elaborated by Diaz (1998). GDP per capita has been obtained from Maddison (2001) and are expressed in 1990 Geary-Khamis dollars. In one of our simulations (see below) we employ estimations for the non-agriculture TFP parameter $A_m$ from Paus, Reinhardt, and Robinson (2003).

At this point it is also important to mention that our sample excludes Argentina, Uruguay and Venezuela for the following reasons. Argentina and Venezuela presented a larger GDP per capita than Chile in the early periods of our study which would indicate that they started the industrialization before the latter country. In addition, Argentina and Uruguay based their economy in an industrialized agricultural sector. Therefore, to appropriately analyze these economies, we would need to include a second type of technology in the agricultural sector that allows for the use of manufactured capital goods, i.e. manufactured farm implements, transport equipment, processing machinery, etc. as in Gollin et.al. (2007).
Table 1
Exogenous parameter values

<table>
<thead>
<tr>
<th>Parameter</th>
<th>$\alpha$</th>
<th>$\theta$</th>
<th>$\delta$</th>
<th>$\gamma_m$</th>
<th>$\beta$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
<td>0.0001</td>
<td>0.5</td>
<td>0.065</td>
<td>0.013</td>
<td>0.95</td>
</tr>
</tbody>
</table>

3.2 Calibration

The parameters $\bar{\alpha}$ and $\gamma_a$ are set to match Chile’s agricultural employment shares in 1890 and 1990. To do this we solve the following system of equations:

\[
\frac{\bar{\alpha}}{(1 + \gamma_a)^{1890}} = 0.4026 \tag{8}
\]

\[
\frac{\bar{\alpha}}{(1 + \gamma_a)^{1990}} = 0.1868 \tag{9}
\]

The numbers 0.4026 and 0.1868 are the agricultural employment shares reported for Chile in our data. Solving equations (8) and (9) we obtain $\bar{\alpha} = 0.4057$ and $\gamma_a = 0.0077$. Based on these values, Chile’s average $A_a$ for 1853-2007 is 0.92. As our numeraire, however, we set $A_a$ (and $A_m$) equal to 1. Initially, we assume $A_m = 1$ for all the countries and focus on the effect of differences in $A_a$.

Following GPR (2002) we also use the following parameter values:

The capital share parameter $\theta$ is set equal to 0.5 following Parente and Prescott (1994, 2000). The depreciation rate $\delta$ takes a typical value for annual depreciation and $\alpha$ is a parameter that must be non-zero so that the economy can accumulate capital starting with no capital. The parameter $\gamma_m$ is set to 0.013 which is the growth rate of output per capita in the United Kingdom over the last 100 years. Asymptotically, this parameter represents the growth of technological progress. Since Latin American countries generally do not produce technology but import it, $\gamma_m = 0.013$ would also be their asymptotic growth rate. The discount factor $\beta$ is chosen so that that the asymptotic annual interest rate is 5 percent.

3.3 Results

The first task is to obtain the values for $A_a$ (agricultural productivity) for each year (whenever data on $N_a$ is available) in each country. To do this we simply replaced the values for $\bar{\alpha}$ and $\gamma_a$ that we previously found in the following equation:
Table 2
Agricultural TFP and year of industrialization

<table>
<thead>
<tr>
<th>Country</th>
<th>$A_a$</th>
<th>$A_m$</th>
<th>Year of Ind</th>
<th>Catch up (90%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chile</td>
<td>1</td>
<td>1</td>
<td>1772</td>
<td></td>
</tr>
<tr>
<td>Brazil</td>
<td>0.6095</td>
<td>1</td>
<td>1836</td>
<td>2043</td>
</tr>
<tr>
<td>Colombia</td>
<td>0.5737</td>
<td>1</td>
<td>1844</td>
<td>2061</td>
</tr>
<tr>
<td>Ecuador</td>
<td>0.536</td>
<td>1</td>
<td>1853</td>
<td>2080</td>
</tr>
<tr>
<td>Peru</td>
<td>0.5227</td>
<td>1</td>
<td>1856</td>
<td>2086</td>
</tr>
<tr>
<td>Paraguay</td>
<td>0.4987</td>
<td>1</td>
<td>1863</td>
<td>2098</td>
</tr>
<tr>
<td>Bolivia</td>
<td>0.4024</td>
<td>1</td>
<td>1891</td>
<td>2146</td>
</tr>
</tbody>
</table>

\[
\frac{\pi}{(1 + \gamma_a)^t N_{at}} = A_{at}
\]  

(10)

We use the average $A_a$ value for each country. In other words, we calibrate $A_a$ so that the model matches the path of agricultural labor share observed in the data.\(^7\) The agriculture TFP values reported in Table 2 are relative values with respect to Chile (which is equal to 1). The year of industrialization in column 3 results from estimating the year in which, according to equation (10) (and using the aforementioned parameters and the average value for $A_a$), $N_a$ is less than 1 for the first time. That is, the year of industrialization is the year in which $N_m$ begins to be greater than zero.

Several interesting implications follow from Table 2. First, a country with a lower agricultural TFP, begins its industrialization process later. Chile, with the highest $A_a$ began its industrialization in 1772. Bolivia, on the other hand, with the lowest $A_a$ began its industrialization in 1891. Brazil and Colombia began to shift labor from the agriculture sector into the non-agriculture sector in 1836 and 1844, respectively.

Second, given that we are assuming that $A_m$ is equal to 1, all income differences will asymptotically vanish, i.e per capita incomes will converge. The last column of Table 2 shows the year in which, according to our estimations, output per capita of each of the selected countries will converge to the 90 percent level of the output per capita of Chile.

As the model predicts, the country with the highest $A_a$, which is Brazil, would be the first to converge to Chile’s income per capita. Brazil will catch up with

\(^7\) We would have liked to compare our calibrations for $A_a$ with previous estimations, but we could not find any such reference. Tamura (2002), for example, discusses the effects of changes in agricultural productivity, but he does not provide any values.
Chile in the year 2043. The process of development is slow. Paraguay that started to industrialize in 1863 will catch up with Chile in 2098. Notice that all of the selected countries take more than 200 years to reach its steady-state relative output levels. As GPR (2002) state, this transition is much slower than what occurs in the one-sector neoclassical growth model. The reason for this difference is that, in our model, labor moves only slowly into the non-agricultural sector.

Before continuing with our numerical experiments we have to make sure that our calibrations based on the labor shares $N_a$ translate also in a good matching of output per capita in each country. The following figures show the adjustment of the model to the data for each country. We compare the agricultural labor shares and also the relative GDP per capita from the data with relative GDP per capita from the model. By relative output per capita we mean output comparisons relative to 1950. There is nothing special about this year, it is chosen just for comparisons and to avoid differences in scale. Relative income is computed using 1995 prices from the benchmark economy.\(^8\)

Despite the model’s simplicity, we can observe that it matches quite closely the development and growth experience over the last 100 years for the seven selected countries. Only for the last years, in particular for Bolivia and Brazil, there is a large mismatching. According to the model Brazil should not have experienced the jump in GDP per capita during the 1950s and 1960s and Bolivia should have grown at higher rates than it actually did. The reason for these mismatches is that the model is not capable to reproduce periods of very high or low growth, i.e. periods in which the changes in TFP are large, because we are assuming a constant TFP in the non-agricultural sector. For instance Bolivia experienced high rates of growth during the 1970s explained by a boost in aggregate TFP, but then during the 1980s it experienced a

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\(^8\) To compute the prices we use the marginal productivity of labor of the agricultural and nonagricultural sectors, we equalize both to the real wages and normalize the price of the agricultural good to 1. As labor can move freely between sectors, we obtain the price of the nonagricultural good.
large recession with negative rates of growth explained by a large decrease in aggregate TFP. Nevertheless, from a quantitative perspective, the model supports the longstanding idea that low agricultural productivity is a major determinant of development.

The following graph shows the years in which all the other countries will catch up with Chile (get to 90 percent of its GDP per capita) assuming $A_m = 1$. Therefore, this exercise focuses exclusively on the effect of the date in which countries industrialize. A country that begins its industrialization later will
start its development later and therefore will take more time to attain higher levels of GDP per capita and close the gap with the leader. This is certainly the case of Bolivia, which is by far the poorest country in the sample.

The next graph and table show the income differences between each country and Chile during the 1990-2000 period. Notice that, not surprisingly, when using the original assumption of $A_m = 1$, the model does not accurately replicate the data. For example, the data shows that Brazil’s GDP per capita was 61 percent of that of Chile during the 1990-2000 period. However, using
A\textsubscript{m} = 1 for Brazil, the model predicts that number to be 85 percent. If we use the manufacturing productivity values reported by Paus, Reinhardt, and Robinson (2003), however, the model predicts exactly 61 percent.

Unfortunately, values for A\textsubscript{m} were only available for Brazil, Colombia, and Peru. For Ecuador, Paraguay and Bolivia, we estimate the values that would generate the best fit of the data. These values are reported in column 5 of Table 3.
Table 3
Relative income in 1990-2000 with different values of non-agricultural TFP

<table>
<thead>
<tr>
<th>Country</th>
<th>Data $M$ ($A_m = 1$)</th>
<th>M (actual $A_m$)</th>
<th>Actual $A_m$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brazil</td>
<td>0.6187</td>
<td>0.8507</td>
<td>0.6141</td>
</tr>
<tr>
<td>Colombia</td>
<td>0.6762</td>
<td>0.8267</td>
<td>0.6231</td>
</tr>
<tr>
<td>Ecuador</td>
<td>0.3779</td>
<td>0.7977</td>
<td>0.3766</td>
</tr>
<tr>
<td>Peru</td>
<td>0.3694</td>
<td>0.7865</td>
<td>0.345</td>
</tr>
<tr>
<td>Paraguay</td>
<td>0.4175</td>
<td>0.7647</td>
<td>0.415</td>
</tr>
<tr>
<td>Bolivia</td>
<td>0.224</td>
<td>0.6502</td>
<td>0.2119</td>
</tr>
</tbody>
</table>

Table 4
Percentage change of non-agricultural TFP to catch up with Chile in 2100

<table>
<thead>
<tr>
<th>Country</th>
<th>$A_a$</th>
<th>Current $A_m$</th>
<th>Needed $A_m$</th>
<th>Dif</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brazil</td>
<td>0.6095</td>
<td>0.8289</td>
<td>0.98</td>
<td>18.23%</td>
</tr>
<tr>
<td>Colombia</td>
<td>0.5737</td>
<td>0.8503</td>
<td>0.99</td>
<td>16.42%</td>
</tr>
<tr>
<td>Ecuador</td>
<td>0.536</td>
<td>0.63</td>
<td>0.993</td>
<td>57.62%</td>
</tr>
<tr>
<td>Peru</td>
<td>0.5227</td>
<td>0.5975</td>
<td>0.994</td>
<td>66.34%</td>
</tr>
<tr>
<td>Paraguay</td>
<td>0.4987</td>
<td>0.69</td>
<td>1</td>
<td>44.93%</td>
</tr>
<tr>
<td>Bolivia</td>
<td>0.4024</td>
<td>0.45</td>
<td>1.03</td>
<td>128.89%</td>
</tr>
</tbody>
</table>

Finally, a typical question in the growth literature, in particular when we are interested in absolute convergence, is: How long would it take a country to close its GDP per capita gap with the leader? Here we slightly modify the question and ask: By how much should the non-agricultural TFP ($A_m$) increase in each country in order to catch up with Chile by the end of this century? In other words we simulate the value of $A_m$ that would allow each country to catch up with Chile in 2100. The results are reported in Table 4.

Brazil, which is the country closer to Chile, will need $A_m = 0.98$ to catch up with it (get to the 90% of Chiles per capita GDP). That represents an 18.23 percent increase in non-agricultural productivity. The same variable will have to increase by 16.42 percent in Colombia to catch up with Chile in 2100. In Bolivia, productivity in sectors like hydrocarbons, mining, manufacturing and others would need to increase by 129 percent, if Bolivia aims to converge to Chile in 2100.
Concluding Remarks

Using a simple model developed by GPR (2002) we show that differences in agricultural and non-agricultural productivity can explain differences in income per capita among a sub-sample of Latin American countries. We perform several exercises comparing the development paths of Brazil, Colombia, Ecuador, Peru, Paraguay and Bolivia with the development path of Chile, our benchmark economy. The model generates series of output per capita (relative to 1950) very similar to the ones displayed using Maddison’s (2001) data.

The basic structure of the GPR (2002) model is that of the one sector neoclassical growth model extended to include an explicit agricultural sector. In this framework, development is associated with industrialization. Industrialization happens only when the country experiences a structural transformation (namely an improvement on agricultural productivity) that withdraws employment from the agricultural sector and moves it into the non-agricultural sector. Asymptotically, agricultures employment share shrinks to zero and the model becomes identical to the standard one-sector neoclassical growth model.

The results show that, according to our calibration, Chile started its industrialization process in 1772, Brazil in 1836, Colombia in 1844, Ecuador in 1853, Peru in 1856, Paraguay in 1863 and Bolivia in 1891. Assuming the same level of non-agricultural productivity for all the economies, these countries will catch up with Chile in 2043, 2061, 2080, 2086, 2098, and 2146 respectively.

If we abandon the assumption of equal levels of non-agricultural productivity and, instead, we use the much lower values reported by Paus, Reinhardt, and Robinson (2003), we show that, for example, Brazil would have to increase its non-agricultural TFP by 18.2 percent in order to catch up with Chile in 2100. The poorest country, Bolivia, in turn, would need to increase its non-agricultural TFP by 129 percent if it aims to catch up with Chile in the same year.

Our research agenda includes the use of the model to study the effect of institutional changes in agriculture that could increase or decrease agricultural productivity (e.g. agrarian reforms).

References


Johnston, Bruce F. and Peter Kilby. 1975. Agriculture and Structural Transformation: Economic Strategies in Late-Developing Countries. New York: Ox-


