“Convergence in Brazil: Recent Trends and Long Run Prospects”

Prof. Afonso Ferreira (UFMG)

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CONVERGENCE IN BRAZIL: RECENT TRENDS AND LONG RUN PROSPECTS

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Afonso Ferreira

Department of Economics, University of Minas Gerais (UFMG), Brazil

Abstract

This paper applies to the analysis of the interstate income distribution in Brazil a set of techniques that have been widely used in the current empirical literature on growth and convergence. Usual measures of dispersion in the interstate income distribution (the coefficient of variation and Theil's index) suggest that σ -convergence was an unequivocal feature of the regional growth experience in Brazil, between 1970 and 1986. After 1986, the process of convergence seems, however, to have slowed down almost to a halt. A standard growth model is shown to fit the regional data well and to explain a substantial amount of the variation in growth rates, providing estimates of the speed of (conditional) β -convergence of approximately 3% p.a.. Different estimates of the long run distribution implied by the recent growth trends point towards further reductions in the interstate income inequality, but also suggest that the relative per capita incomes of a significant number of states and the number of "very poor" and "poor" states were, in 1995, already quite close to their steady-state values.

Current address: 25 Wimpole Road – Beeston Nottingham NG9 3LQ United Kingdom; e-mail: afonsoferreira@compuserve.com.

1. INTRODUCTION

This paper applies to the analysis of the interstate income distribution in Brazil a set of techniques that have been widely used in the current empirical literature on growth and convergence. The recent trends in the interstate income distribution are analysed in Section 2, while Section 3 presents the results of two exercises which attempt to determine the long run shape of the distribution implied by those trends. Some conclusions are suggested in Section 4.

2. RECENT TRENDS IN THE INTERSTATE INCOME DISTRIBUTION IN BRAZIL¹

2.1 σ -Convergence

Economic activity in Brazil is concentrated in a relatively small portion of the territory. In 1995, the four states located in the Southeast, which occupy together only 11% of the country's area, accounted for 43% of the population and 57% of the Brazilian GDP (Table 1).

More important, the differences in per capita incomes (PCIs) across states and regions are significant. Brazil's per capita income, evaluated at the current exchange rate, amounted to US\$ 3 953, in 1995. The PCI of the richest state (Distrito Federal), at US\$ 7 946, was two times higher than the national mean and more than seven times higher than the per capita income of the poorest state (US\$ 1 067, in Piauí). While the per capita income of the Northeast, the poorest region, was less than half the country's mean, the Southeast had a PCI 34% higher than the national average (Tables 2 and 3).

Although, as indicated above, spatial concentration is still high, the geographical distribution of production changed significantly, in the last 25 years, with the GDP share of the

Southeast falling from 65% to 57%, while the shares of all other regions, especially the North and Centre-West, increased (Table 1).

Figure 1 shows that the dispersion of the state per capita incomes around the national mean has also been reduced, in the past 25 years. The variables RATIO70 and RATIO95 in that figure are the ratios of the state PCIs to the national mean, in 1970 and 1995, respectively, ordered according to their 1970 values. As can be readily seen from Figure 1, for 20 of the 25 states, RATIO95 is closer to 1 than RATIO70.

The information regarding the differences in state per capita incomes, shown in Figure 1, can be summarised in a single measure of the degree of inequality in the interstate income distribution - Theil's inequality index, given by:

$$L = \sum p_i \ln (y_i/p_i) \quad (1)$$

where p_i = share of the i^{th} state in the country's population, y_i = share of the i^{th} state in the country's GDP, $\sum$ = sum operator and $\ln$ = natural logarithm.

For a perfectly egalitarian income distribution, defined as the situation in which all states have the same per capita income, the value of Theil's index will be zero. While this is the minimum value that can be taken by the index, there is no maximum value defined for it.

The estimated value of Theil's index for the Brazilian interstate income distribution in 1995 is 0.116, with the *inter*-regional differences in per capita incomes accounting for 75% of the total inequality among the states and the *intra*-regional differences playing a relatively minor role (25%) in explaining the value found for the index (Ferreira, 1998).

Annual estimates of Theil's index, for the period 1970/1995, suggest that σ -convergence, i.e. a reduction in the dispersion of the PCIs around the national mean, took place among the Brazilian states, at a relatively fast speed, between 1975 and 1986. After 1986, this index still tends to decline, but now only at a very slow pace (Table 3)².

Increased equality in the *inter*-regional distribution (61%) and the convergence of per capita incomes within the Southeast (31%) together account for 92% of the reduction in the Theil's index, between 1970 and 1995. The remaining 8% are explained by the reduction in inequality which also occurred within the other four regions (Ferreira, 1998).

2.2 β -Convergence

An inverse relationship between the growth rates of the state per capita incomes and the initial PCI levels, what has been termed β -convergence, is a necessary (but not sufficient) condition for σ -convergence. Figure 2 shows that, as already could be inferred from the results presented in the previous section, β -convergence can be observed among the Brazilian states, in the period 1970/1995.

The equation for the straight line adjusted to the data in Figure 2 is shown as Equation 4.1, in Table 4, where GROWTH = annual rate of growth of the state per capita incomes between 1970 and 1995 and INPCI = natural logarithm of the state per capita income levels in 1970 (measured in dollars of 1995).

The sign and statistical significance of the coefficient on the 1970 income levels suggest the existence of (at least as a first approximation, unconditional or absolute) β -convergence among the Brazilian states, in the period under analysis. This result is in line with

the recent empirical literature, which, in general, has detected absolute β -convergence within sets of “more similar” economies, such as states or regions of the same country (Sala-i-Martin, 1996).

The speed of convergence of 1.0%, implied by the value of the coefficient on INPCI, however, is well below the estimates of Sala-i-Martin (1996) for the US states (2.1%), the Japanese prefectures (1.9%) and 90 regions in Europe (1.5%)³.

The value of β increases substantially when other variables, which are usually assumed to determine per capita income in the steady-state, are introduced in the convergence regression. Steady-state per capita income depends on the steady-state level of labor productivity and on the rate of participation in the labor force. Long run productivity, following Mankiw, Romer and Weil (1992), is, in turn, presumed here to be determined by the rate of investment, a measure of the stock of human capital (average schooling) and the rate of growth of the labor force. Estimates of this standard specification for the per capita growth equation are presented in Tables 4, 5, 6 and 7.

The equations in Tables 4, 5 and 6 are cross-section regressions, referring to the period 1970/1995 (Table 4) and to the sub-periods 1970/80 (Table 5) and 1980/95 (Table 6). The equations in Table 7 are pooled time series cross-section regressions, estimated by pooling the data used in the regressions in Tables 5 and 6.

In each of those equations, GROWTH and GEAP are the average annual rates of per capita income growth and labour force growth, in the corresponding period of estimation. The variables INVRATE, SCHOOL and PART, in Tables 5, 6 and 7, are initial year (i.e. either 1970 or 1980) values of the rate of investment, the average number of years of schooling of

the economically active population (EAP) and the rate of participation in the labour force (EAP/population)⁴. In Equations 4.3-4.5, INVRATE was given by the average of the rate of investment in 1970 and 1980, while SCHOOL and PART came from averaging the information on schooling and the rate of participation for the years 1970, 1980 and 1995⁵.

Following Sachs and Warner (1997), a non-linear relationship between schooling and growth was assumed in all regressions. We expect a positive sign for the coefficient on SCHOOL and a negative sign for the coefficient on SCHOOLSQ (= SCHOOL squared), so that, other things equal, growth will be higher in states with an intermediate level than in states with very low or very high (in Brazilian terms) levels of schooling.

A time effect, consisting of a dummy variable, with a value of zero, in the period 1970/80, and a value of 1, in the period 1980/95, was added to the pooled regressions, in Table 7, to control for the substantial difference in the macroeconomic environment between the two periods (the 1970s were the years of the Brazilian “miracle”, a decade during which the Brazilian GDP per capita increased by 82%, while the post-1980 years can be characterized as a period of acute macroeconomic instability and stagnation of per capita output⁶).

The pooled regressions also included an interaction term, allowing for a change in the coefficient of the initial per capita income levels between the two periods.

Finally, two dummy variables, for the states of Amazonas and Amapa, with a value of 1 for those states in the period 1970/80 and zero otherwise, were added to Equations 7.1-7.3⁷.

All RHS variables, with the exception of the dummies, entered the regressions in log form. In all cases, estimation was by OLS. The figures in parentheses bellow the regression coefficients are t-statistics calculated from heterocedasticity-consistent standard errors, while

the figures in the rows Normality, W and RESET are p-values for Jarque-Beras's test of normality of the residuals, White's heterocedasticity test and Ramsey's test of model specification, respectively.

Because of lack of data on schooling, the state of Acre was not included in the regressions. Given the idiosyncratic nature of employment and economic activity in its area (which corresponds to Brasilia, the nation's capital), the Distrito Federal was also excluded from the calculations.

The regressions, in Tables 4, 5, 6 and 7, explain a considerable proportion of the variation in growth rates, in the different periods to which they refer. The cross-section regressions in Table 4, for example, account for approximately three quarters of the variation in growth rates, in the 25 years under analysis.

The coefficients on the RHS variables display, in general, the theoretically predicted signs, the only exception here being the coefficient on the rate of labour force growth, in Equation 6.2, which, however, is not significantly different from zero.

The value of the speed of conditional convergence implied by the coefficients on the initial income levels varies widely, from around 3%, in the cross-section regressions referring to the whole 1970/95 period (Equations 4.3-4.5) to more than 7%, in the estimates for the 1970s (Equations 5.2-5.4), but is always considerably higher than that derived from the absolute convergence regressions (Equations 4.1, 4.2, 5.1 and 6.1)⁸.

The coefficients on the rate of investment and the rate of labour force growth are not significantly different from zero, whenever a full specification of the growth equation is adopted (Equations 4.3, 5.2, 6.2 and 7.1). However, when the regressions are reestimated, with

one of those two variables excluded from the RHS, the statistical significance of the coefficient on the remaining variable, in some cases, becomes high enough to make it possible to reject the null hypothesis of a value of zero for it, at the 10% level, in a one side t-test (Equations 4.5, 5.3, 7.2 and 7.3). A negative correlation between the two variables, which is a possible explanation for these results, would seem to be consistent with the notion that capital and labour move in opposite directions, when there are differences in labour productivity (and, therefore, in per capita incomes) among regions of the same country.

The coefficients on the schooling variables, in Equations 4.3-4.5 and Equations 7.1-7.3, which give estimates for the whole period under analysis, suggest that the effect of education on growth reaches a maximum at an average level of schooling between 4 and 5 years (the highest level of average schooling, in 1995, was 7.45 years, in the state of Rio de Janeiro).

The results obtained also indicate that, as expected, per capita income growth is positively correlated with the rate of participation in the labour force.

The intercept dummy, in the pooled regressions in Table 7, has the expected negative sign, confirming that, other things equal, growth rates tended to be lower in the post-1980 years than in the 1970s, due to the poor macroeconomic conditions prevailing in the former period.

The interaction term in those regressions has a positive sign, suggesting that the states were approaching their steady state levels of per capita income at a slower pace, after 1980 (Equations 7.1-7.3). A similar conclusion is suggested by a comparison of the estimates of the speed of conditional convergence in Tables 5 and 6 (more than 7% , for the period 1970/80,

and less than 4%, for the post-1980 years). Absolute convergence, however, again according to Tables 5 and 6 (Equations 5.1 and 6.1), was faster after 1980 than in the 1970s.

An interpretation that reconciles these two seemingly contradictory results goes as follows. In the 1970s, a decade of generally high rates of per capita income growth, convergence was restricted mainly to the states located in the Southeast, South and Centre West regions (only in 5 of the 15 states located in the North and Northeast, the poorest regions, the per capita income gap with respect to the national average was reduced in this period). After 1980, simultaneously to the dramatic reduction in growth rates, the speed of convergence among the rich states decelerated, while the poor states, in the North and Northeast, started to catch up. As a consequence of these different influences, the estimates of the speed of absolute and conditional convergence moved in opposite directions, between the two periods.

The results described in this section are, in general, consistent with the hypothesis of conditional β -convergence, i.e. with the notion that only states with similar structural characteristics (here represented by the propensity to invest, the stock of human capital, the rate of labor force growth and the rate of participation) converge to the same steady-state level of per capita income. The main implications of these results for the convergence prospects in Brazil will become clear in Section 3.

3. THE LONG RUN INTERSTATE INCOME DISTRIBUTION IN BRAZIL: PROJECTIONS FROM RECENT TRENDS

What is the long run shape of the interstate income distribution implied by the tendencies just described? What can we expect that distribution to be, in the steady state, given the regional growth experience in Brazil, in the last 25 years?

Jones (1997) suggests that the long run distribution of income among a set of economies can be inferred from the *principle of transition dynamics*, the proposition according to which an economy's per capita income should grow at a rate proportional to the gap between its current and steady state values. Naming the factor of proportionality as the "speed of convergence", we have:

$$\begin{aligned} \text{growth of state } i\text{'s relative per capita income} &= \text{speed} \\ \text{of convergence} \times \text{percentage gap to own steady state} & \end{aligned} \quad (2)$$

where the relative per capita income is the ratio of state i 's PCI to the highest state PCI.

The expression in (2) constitutes the main pillar of the recent empirical literature on conditional β -convergence and has motivated a large volume of research, in which, as in the previous section of this paper, econometrics has been employed to provide estimates of the speed of convergence and to explain differences in growth rates.

In an alternative application, given data on growth rates and initial PCIs and some assumption regarding the speed of convergence, that expression could be used to calculate the distribution of the steady state (relative) per capita incomes.

The results of such an exercise, based on information available for the Brazilian states, are presented in Table 8.

The first two columns in that table report the actual relative state per capita incomes with respect to Sao Paulo (the largest and most successful state economy), in 1970 and 1995. The long run estimates, shown in the last three columns, were derived from data on the relative per capita income levels in 1970 and growth rates for the period 1970/1995, assuming values for the speed of convergence of 4%, 5% and 6%.

When the speed of convergence is presumed to be 5%, the implied steady-state relative per capita incomes are practically equal to the current (1995) relative PCIs and further gains with respect to Sao Paulo are expected only for a very small group of states.

A value of β equal to 6% would result in all states, except the state of Rio de Janeiro, moving toward levels of relative income, in the long run, lower than those reached in 1995, a scenario that does not seem to be too realistic.

A value of β equal to 4%, on the other hand, would give a relatively optimistic view of the prospects for a reduction in the gap between Sao Paulo and the other state economies, in the long run. Note, however, that even in this case, for a non-negligible number of states, including some of the poorest states in the Northeast, the predicted gains seem small (specially when compared to those of the period 1970/95), which means that the current relative PCIs in those states might be already quite close to their steady-state values.

Finally, values of the speed of convergence below 4% result in implausibly high estimates of the long run relative per capita income for some states and are, therefore, discarded (in this respect, see also Jones (1997)).

Are values of β in the 4%-6% range compatible with the econometric analysis conducted in Section 2.2? A Wald test of the hypothesis that the coefficient on the initial

income levels in Equation 4.5, in Table 4, is equal to -2.528 (the value of that coefficient which would correspond to an implied $\beta=4\%$) gives a p-value of 52%. Similar tests for the cases of $\beta=5\%$ and $\beta=6\%$ result in p-values of 22% and 10%, respectively.

The estimates of the long run interstate income distribution derived from the hypotheses of $\beta=4\%$ and $\beta=5\%$ not only seem to be consistent with the previous econometric results but also constitute, at least in the context of the present exercise, the most intuitively plausible interval in which the state PCIs may be expected to be found in the long run, given the recent trends observed in the interstate distribution.

Another procedure that can be used to “forecast” the shape of the long run income distribution is based on Markov transition analysis and was first applied to the study of convergence by Quah (1993a, 1993b)⁹.

The Markov approach assumes that, given I possible income levels, each state has a probability $p_i(t)$ of being in level I at time t and a transition probability $m_{ij}(t)$ of being in level j at time $t+1$. Assuming, for simplicity, that the transition probabilities do not change over time and ordering them as the $I \times I$ transition matrix M , we get:

$$p(t+1) = p(t)M = p(0)M^t \quad (3)$$

where $p(t)$ is a $1 \times I$ row vector whose elements are the time-dependent probabilities $p_i(t)$ and M^t is the product of t identical M matrices.

The solution to this exercise consists in determining the $1 \times I$ row vector s such that:

$$s = s M$$

(4)

where s characterises the likely long run distribution of cross-state incomes (European Commission, 1997).

This approach has some advantages with respect to the conventional tests of σ and β -convergence adopted in Sections 2.1 and 2.2 as well as with respect to the exercise reported in Table 8. First, it provides information on what is happening to the entire cross-section of (state) economies, i.e. it does not focus on any particular economy but on the shape of the distribution as a whole (Quah, 1996; Jones, 1997). Second, “[it] provides evidence on persistence and stratification; on the formation of convergence clubs; and on the cross section distribution polarising into twin peaks of rich and poor” (Quah, 1996, pp. 1046)¹⁰. Finally, it does not assume that the states are growing toward constant targets, admitting, instead, shifts in the steady state positions. In this sense, it provides a prediction of the very long run income distribution (Jones, 1997).

To perform this exercise, I have assumed that, at any point in time, a state can be found in one of the following five situations, defined by its relative per capita income level: “very poor” (state PCI below 50% of the national mean); “poor” (state PCI between 50% and 80% of the national mean); “medium” (state PCI between 80% and 120% of the national mean); “rich” (state PCI between 120% and 150% of the national mean); “very rich” (state PCI above 150% of the national mean)¹¹.

The Markov analysis requires first the construction of the two way $I \times I$ cross-tabulation reproduced in Table 9, in which the counts are the number of states in the situation i in 1970

and situation j in 1995¹². The second step is to derive, from the frequencies observed in Table 9, the estimates of the m_{ij} transition probabilities that appear in Table 10.

In the period 1970/1995, a majority of states (fourteen in a total of twenty five) were “movers”. As shown in Table 9, five of the “very poor” and five of the “poor” states, in 1970, had moved to the immediately superior income category by 1995. Four states, on the other hand, descended, in the per capita income ladder, to categories inferior to the ones in which they found themselves in 1970. The other eleven states (among them, five of the “very poor” and two of the “very rich” states, in 1970) were “stayers”, remaining in the same situation throughout.

Using the transition probabilities in Table 10, the equilibrium probability vector, giving the proportion of states at each of the five income levels in the steady state, was estimated. The results are shown in Table 11, together with the 1970 and 1995 actual distributions.

Table 11 suggests a tendency for the Brazilian states to move towards the middle income categories. The proportion of “very poor” states, which fell from 40% to 20%, between 1970 and 1995, is predicted to become zero in the long run. Similarly, for the “very rich” and “rich” states, the figures in Table 11 add up to 16%, in 1970, 12%, in 1995, and, again, zero, in the steady state. The percentages of states in the “poor” and “medium” income intervals, in turn, are expected to increase from 32% and 12%, in 1970, to 52% and 48%, respectively, in the very long run. Although a substantial reduction in the interstate income inequality is predicted by this exercise, absolute β -convergence does not result, i.e. the states are not expected to converge to an identical per capita income level in the long run.

An obvious flaw of the exercise reported in Tables 9-11 is the small number of observations. The results in those tables were derived from data for the years 1970 and 1995 and, thus, refer to 25 year transitions. Tables 12-13 report the results of a similar exercise, based on the 5 year transitions observed for the periods 1970/75, 1975/80, 1980/85, 1985/90 and 1990/95. The two exercises, thus, differ in two respects: the number of observations (25, in the first case; 125, in the second) and the time horizon of the observed changes from which the transitions matrices were derived (25 year changes and 5 year changes, respectively). A third difference consists in that, in the second exercise, the "medium" income group was partitioned in two different categories ("below the national average" and "above the national average").

Comparing the entries in the main diagonals in Tables 10 and 12, we find, as expected, higher persistence in the latter table than in the former. Both tables suggest a tendency for the "very rich" and "rich" states to move toward lower levels of (relative) income and no tendency for the states in the "medium" or lower (relative) income levels to move in the opposite direction (i.e. toward the "rich" and "very rich" categories). Table 12, however, differs from Table 10 in that there is a 5% probability for the "poor" and "below average" states to fall to the "very poor" income group.

As a consequence, while the long run distribution in Table 13, as that in Table 11, does not display any "very rich" and "rich" strata, it does contain a "very poor" group of states. A second distinctive feature of the results in Table 13 is that the expected proportions of states in the two lower categories is quite similar to the actual proportions observed in 1995. The long

run distributions, in both tables, are, in any case, characterised by the same concentration of states in the “poor” and “medium” income levels, i.e. by some degree of convergence.

4. CONCLUSIONS

The main results derived in this paper are:

- 1) The usual measures of dispersion in the interstate income distribution suggest that σ -convergence was an unequivocal feature of the regional growth experience in Brazil, between 1970 and 1986. The process of convergence seems, however, to have slowed down almost to a halt, after 1986.
- 2) A standard growth model, in which per capita income growth is assumed to depend on the initial income level, the rate of investment, average schooling, the rate of growth of the labour force and the rate of participation, explains a substantial amount of the variation in growth rates in the period 1970/95. It should be noted, however, that the performance of the model was not as satisfactory when only data for the 1980/95 years (a period characterised by low growth rates and high economic instability) were used in its estimation.
- 3) The results of the growth regressions are consistent with the hypothesis of conditional β -convergence, the proposition that (only) states with similar structural characteristics tend towards the same steady state per capita income level. As predicted by the model, the rates of growth were found to vary directly with the rate of investment, average schooling and the rate of participation and inversely with the initial income level and the rate of growth of the labour force. The

relationship between schooling and per capita income growth is non-linear, with intermediate levels of schooling having a higher impact on growth than low or high levels.

- 4) The point estimate for the speed of (conditional) convergence, when data for the entire 1970/95 period were used in the estimation, was approximately 3%. Conditional convergence seems to have been faster in the 1970s than after 1980.
- 5) Some evidence was found of a negative correlation between the rate of investment and the rate of growth of the labour force, a result consistent with the theoretical predictions regarding factor mobility, in the neoclassical model.
- 6) Different estimates of the long run interstate income distribution pointed towards a tendency for the great majority of states to cluster in the interval between 50% and 120% of the national average (100% of the states, in Table 11, and 82%, in Table 13 – against 44%, in 1970, and 68%, in 1995). Therefore, while we may expect, on the basis of the trends observed between 1970 and 1995, further reductions in the interstate income inequality, the data again do not support the hypothesis of absolute β -convergence.
- 7) Some exercises have suggested that the relative per capita incomes of a significant number of states (Table 8) and the number of “very poor” and “poor” states (Table 13) were, in 1995, already quite close to their steady state values. These results offer a possible explanation for the apparent weakening of the process of convergence which has been observed since 1986.

NOTES

1. Previous work on the interstate income distribution in Brazil includes Azzoni (1994, 1996), Ellery Jr. and Cavalcanti Ferreira (1994), Ferreira and Diniz (1995), Ferreira (1996) and Ferreira (1998).

2. The coefficient of variation (standard deviation normalized by the mean) of the state PCIs also fell, from 0.645, in 1970, to 0.462, in 1986, and increased slightly, afterwards, to reach a level of 0.494, in 1995 (Table 3). The coefficient of variation is the measure of σ -convergence most commonly adopted in the literature. I have, however, opted for emphasizing here the results based on Theil's index, because this index has the desirable feature of weighting the (relative) state per capita incomes by the states' shares in the total population. In any case, the evolution of the coefficient of variation was similar to that of the L index, during most of the period under analysis.

3. The speed of convergence β can be inferred from the coefficient b in the regression $\text{GROWTH} = a - b \text{ INPCI}$, since $b = [100/T] [1 - e^{-\beta T}]$, where T is the time interval between the two observations used to estimate the average annual rates of growth, corresponding to 25 years, in this case (Sachs and Warner, 1997). Other country estimates of the speed of absolute convergence reported in Sala-i-Martin (1996) are: Germany (1.4%), United Kingdom (2.0%), France (1.6%), Italy (1.0%) and Spain (2.1%).

4. Direct information on *total* investment at the state level is not available. Data on *industrial* investment (mining + manufacturing), however, can be found for the years 1970 and 1980. A proxy for *total* state investment, in those two years, was, thus, constructed by assuming that the share of a state in the country's capital formation was the same as its share in *industrial* investment.

5. Mankiw, Romer and Weil (1992), among many others, also average the information on the right hand side (RHS) variables in their estimates of growth regressions. Endogeneity, specially in relation to the rate of investment, may, however, be a concern in this case. That is one of the reasons why regressions using initial year values of the rate of investment, schooling and the rate of participation, as well as regressions in which the rate of investment was excluded from the RHS, are also reported. The steady state level of labor productivity depends on the steady state level of human capital, not on its initial period value or average value during the period of estimation (Mankiw, Romer and Weil, 1992). To take this into account, equations were estimated where final year values of SCHOOL were used (Islam, 1995). These latter results, which do not depart significantly from those shown in Tables 4-7 are available from the author upon request.

6. The average annual rate of per capita GDP growth fell from 6.6%, in the 1970s, to 0.1%, in the period 1980/95. This context of low growth rates and high uncertainty and instability, perhaps, explains why the performance of the model was, in general, less satisfactory, when only data for the post-1980 years were used in its estimation (Equations 6.2-6.4).

7. Those were the states with, respectively, the highest (9.8%) and lowest (1.9%) rates of per capita income growth in the 1970s. The impressive growth performance of the state of

Amazonas is explained by the creation of the Zona Franca de Manaus, a duty-free area specialising mainly in the production of durable consumption goods (electrical appliances and electronics) for the domestic market.

8. As it is well known, these higher (conditional) values of β refer to the speed at which the state PCIs are moving toward their own steady-state values, which may differ across states and regions. What Islam (1995) observed with respect to the world income distribution also seems to apply here: there may be little solace to be derived from finding that the Brazilian states are converging at a faster rate, if the points to which they are converging may remain very different.

9. This technique has also been recently employed to determine the impact of the Single Market Programme on the distribution of income and convergence among 169 regions in Europe (European Commission, 1997) and adopted by Jones (1997) in his study of the world income distribution.

10. According to Quah, this is the main deficiency of the σ -convergence tests: on the basis of such tests, it is not possible to uncover intra-distribution movements, the existence of convergence clubs, "twin-peaks dynamics" etc. With respect to the β -convergence tests, Quah argues that "the cross-section correlation between growth rates and income levels reveals even less, its interpretation being plagued by a version of Galton's Fallacy" (Quah, 1996 and also 1993b).

11. Since the per capita incomes of even the richest states in Brazil are well below those of the developed countries, the notions of "rich" and "very rich" adopted here, obviously, only make sense when related to the Brazilian context.

REFERENCES

- Azzoni, Carlos (1994). Crescimento econômico e convergência das rendas regionais: o caso brasileiro, *Anais do XXIIº Encontro Nacional de Economia (ANPEC)*, vol. 1, pp. 185-205.
- Azzoni, Carlos (1996). Economic growth and regional income inequalities in Brazil (1939-1992), University of Sao Paulo, mimeo.
- European Commission (1997). Regional growth and convergence, *The Single Market Review*, subseries VI, vol. 1. Office for Official Publications of the European Communities/Kogan Page-Earthscan.
- Ellery Jr., Roberto and Pedro Cavalcanti Ferreira (1994). Crescimento econômico e convergência entre as rendas dos estados brasileiros, *Anais do XVIº Encontro Brasileiro de Econometria (SBE)*, pp. 264-286.
- Ferreira, Afonso and Clelio Diniz (1995). Convergência entre as rendas per capita estaduais no Brasil, *Revista de Economia Política* 15(4), pp. 38-56.
- Ferreira, Afonso (1996). A distribuição interestadual da renda no Brasil (1950-85), *Revista Brasileira de Economia* 50(4), pp. 469-485.
- Ferreira, Afonso (1998). Evolução recente das rendas per capita estaduais no Brasil, *Revista de Economia Política* 18(1), pp. 90-97.
- Islam, Nazrul (1995). Growth empirics: a panel data approach, *Quarterly Journal of Economics* 110, pp. 1127-1170.
- Jones, Charles (1997). On the evolution of the world income distribution, *Journal of Economic Perspectives* 11(3), pp. 19-36.
- Mankiw, N. D. Romer and D. Weil (1992). A contribution to the empirics of economic growth, *Quarterly Journal of Economics* 107(2), pp. 407-437.
- Quah, Danny. (1993a). Empirical cross-section dynamics in economic growth, *European Economic Review* 37, pp. 426-434.
- Quah, Danny (1993b). Galton's fallacy and tests of the convergence hypothesis, *Scandinavian Journal of Economics* 95(4), pp. 427-443.
- Quah, D. (1996). Twin peaks: growth and convergence in models of distribution dynamics, *Economic Journal* 106, pp. 1045-1055.

Sachs, Jeffrey and Andrew Warner (1997). Fundamental sources of long run growth, *American Economic Review* 87(2), pp. 184-188.

Sala-i-Martin, Xavier. (1996). The classical approach to convergence analysis, *Economic Journal* 106, pp. 1019-1036.

TABLE 1 - BRAZIL - REGIONAL SHARES IN AREA, POPULATION AND GDP - 1970 and 1995 - (%)

REGION	AREA	POPULATION		GDP	
		1970	1995	1970	1995
NORTH	42.0	3.9	6.4	2.2	4.7
NORTHEAST	18.2	30.2	28.6	12.0	13.7
SOUTHEAST	10.8	42.8	42.7	65.0	57.2
Sao Paulo	2.9	19.1	21.7	39.4	35.8
SOUTH	6.8	17.7	15.0	17.0	17.4
CENTRE-WEST	22.1	5.4	7.3	3.7	7.1
TOTAL*	100.0	100,0	100,0	100,0	100,0

* the addition may not be exact due to rounding errors.

Area = 8,544,516 km²; Population in 1995 = 154.9 million; 1995 GDP at current prices = US\$ 612.2 billion

TABLE 2 - BRAZIL - REGIONAL GDP PER CAPITA RELATIVE TO THE NATIONAL AVERAGE

REGION	1970	1995
NORTH	0.58	0.72
NORTHEAST	0.40	0.48
Piaui	0.21	0.27
SOUTHEAST	1.52	1.34
Rio de Janeiro	1.66	1.22
Sao Paulo	2.06	1.65
SOUTH	0.96	1.16
CENTRE-WEST	0.68	0.97
Distrito Federal	1.79	2.01

GDP PER CAPITA in 1995, at current prices = US\$ 3 953

**TABLE 3 - BRAZIL - INTERSTATE INCOME
DISTRIBUTION - 1970/1995**

YEAR	Theil's Index	Coefficient of variation (standard deviation/ mean)	Richest State PCI*/ Poorest State PCI ⁺
1970	0.216	0.645	9.75
1975	0.203	0.662	8.90
1980	0.164	0.564	8.44
1985	0.128	0.494	7.04
1986	0.119	0.462	6.33
1987	0.122	0.471	6.57
1988	0.123	0.485	7.03
1989	0.120	0.504	8.21
1990	0.119	0.488	7.16
1991	0.117	0.475	7.37
1992	0.119	0.483	7.56
1993	0.116	0.483	7.12
1994	0.111	0.480	6.99
1995	0.116	0.494	7.38

*Sao Paulo, until 1987, and Distrito Federal,
from 1988 to 1995; +Piaui

TABLE 4 - BRAZIL - TESTS OF β -CONVERGENCE - CROSS-SECTION RESULTS - 1970/95 (dependent variable = GROWTH)

RHS VARIABLES	Eq.4.1	Eq.4.2	Eq.4.3	Eq.4.4	Eq.4.5
Constant	9.790 (5.803)	10.568 (6.366)	-9.579 (-1.769)	-9.062 (-1.729)	-10.656 (-1.800)
INPCI	-0.904 (-3.784)	-1.021 (-4.370)	-2.048 (-3.168)	-1.953 (-3.670)	-2.172 (-4.029)
INVRATE			0.153 (0.512)		0.261 (1.491)
SCHOOL			13.227 (2.869)	14.208 (4.733)	12.028 (4.599)
SCHOOLSQ			-4.525 (-2.206)	-4.931 (-3.545)	-4.026 (-3.207)
GEAP			-0.268 (-0.427)	-0.408 (-0.960)	
PART			5.038 (3.146)	4.733 (3.446)	5.573 (4.617)
β	1.024	1.179	2.869	2.679	3.133
number of observations	25	23	23	23	23
Adjusted R ²	0.363	0.410	0.718	0.731	0.729
Normality	0.453	0.467	0.819	0.586	0.961
W	0.674	0.849	0.558	0.533	0.553
RESET	0.208	0.104	0.747	0.811	0.631

Definition of the variables: GROWTH = average annual rate of per capita income growth (1970/95); INPCI = per capita income levels in 1970; INVRATE = average of the rate of investment in 1970 and 1980; SCHOOL = average of years of schooling in 1970, 1980 and 1995; GEAP = average annual rate of growth of the labour force (1970/1995); PART = average of the rate of participation in 1970, 1980 and 1995.

TABLE 5 - BRAZIL - TESTS OF β -CONVERGENCE - CROSS-SECTION RESULTS - 1970/80 (dependent variable = GROWTH)

RHS VARIABLES	Eq.5.1	Eq.5.2	Eq.5.3	Eq.5.4
Constant	12.763 (3.554)	-16.555 (-0.911)	-14.468 (-0.835)	-19.737 (-1.258)
INPCI	-0.826 (-1.561)	-5.360 (-2.613)	-5.153 (-2.893)	-5.867 (-3.317)
INVRATE		0.277 (0.454)		0.562 (1.234)
SCHOOL		14.321 (4.610)	14.957 (5.513)	13.464 (4.848)
SCHOOLSQ		-5.673 (-3.050)	-6.018 (-4.242)	-5.102 (-3.223)
GEAP		-0.733 (-0.736)	-1.034 (-1.480)	
PART		16.191 (2.036)	15.423 (2.113)	17.727 (2.709)
β	0.862	7.678	7.243	8.836
number of observations	23	23	23	23
Adjusted R ²	0.014	0.402	0.431	0.423
Normality	0.709	0.310	0.473	0.219
W	0.164	0.763	0.605	0.718
RESET	0.310	0.107	0.097	0.261

Definition of the variables: GROWTH = average annual rate of per capita income growth; INPCI = per capita income levels in the initial year; INVRATE = rate of investment in the initial year; SCHOOL = years of schooling in the initial year; GEAP = average annual rate of growth of the labour force; PART = rate of participation in the initial year.

TABLE 6 - BRAZIL - TESTS OF β -CONVERGENCE - CROSS-SECTION RESULTS - 1980/95 (dependent variable = GROWTH)

RHS VARIABLES	Eq.6.1	Eq.6.2	Eq.6.3	Eq.6.4
Constant	11.546 (5.977)	7.588 (0.978)	13.658 (3.691)	13.470 (3.799)
INPCI	-1.363 (-5.660)	-2.940 (-3.479)	-2.316 (-4.220)	-2.232 (-4.291)
INVRATE		0.260 (0.514)		
SCHOOL		7.101 (1.667)	7.175 (2.872)	6.107 (2.459)
SCHOOLSQ		-1.933 (-1.063)	-2.195 (-2.104)	-1.724 (-1.679)
GEAP		0.558 (0.891)		
PART		2.557 (1.064)		
SERGIPE				2.145 (13.522)
β	1.524	3.877	2.844	2.718
Number of Observations	23	23	23	23
Adjusted R ²	0.496	0.507	0.555	0.744
Normality	0.042	0.004	0.008	0.416
W	0.616	0.981	0.782	0.929
RESET	0.309	0.562	0.397	0.479

Definition of the variables: GROWTH = average annual rate of per capita income growth; INPCI = per capita income levels in the initial year; INVRATE = rate of investment in the initial year; SCHOOL = years of schooling in the initial year; GEAP = average annual rate of growth of the labour force; PART = rate of participation in the initial year; SERGIPE = dummy variable with value of 1 for the state of Sergipe and zero otherwise.

TABLE 7 - BRAZIL - TESTS OF β -CONVERGENCE - POOLED ESTIMATION - 1970/95 (dependent variable = GROWTH)

RHS VARIABLES	Eq.7.1	Eq.7.2	Eq.7.3
Constant	15.602 (1.421)	13.937 (1.314)	17.400 (1.854)
DUMMY	-13.738 (-3.856)	-13.929 (-3.873)	-14.087 (-4.149)
INPCI	-4.235 (-6.547)	-4.497 (-5.992)	-3.848 (-6.102)
DUMMY* INPCI	1.062 (2.371)	1.082 (2.401)	1.114 (2.601)
INVRATE	0.422 (1.016)	0.550 (1.431)	
SCHOOL	9.666 (4.340)	9.214 (4.584)	10.695 (5.915)
SCHOOLSQ	-3.129 (-2.636)	-2.853 (-2.609)	-3.776 (-4.118)
GEAP	-0.366 (-0.639)		-0.785 (-1.427)
PART	4.610 (1.328)	5.429 (1.606)	3.696 (1.274)
Number of Observations	46	46	46
Adjusted R ²	0.922	0.923	0.921
Normality	0.815	0.853	0.817
W	0.582	0.288	0.533
RESET	0.694	0.684	0.581

Definition of the variables: GROWTH = average annual rate of per capita income growth in 1970/80 and 1980/95; INPCI = per capita income levels in 1970 and 1980; INVRATE = rate of investment in 1970 and 1980; SCHOOL = years of schooling in 1970 and 1980; GEAP = average annual rate of growth of the labour force in 1970/80 and 1980/95; PART = rate of participation in 1970 and 1980; DUMMY = 0, in the period 1970/80, and 1, in the period 1980/95. Dummy variables, with a value of 1 for the states of Amapa and Amazonas and zero otherwise, in 1970/80, were also included in the regressions.

**TABLE 8 - BRAZIL - LONG RUN ESTIMATES OF THE STATES
RELATIVE PER CAPITA INCOMES**

STATES	RELATIVE INCOMES*				
	1970	1995	Long Run		
			$\beta=4$	$\beta=5$	$\beta=6$
RONDONIA	0.42	0.47	0.47	0.46	0.45
ACRE	0.28	0.47	0.58	0.48	0.43
AMAZONAS	0.34	0.52	0.59	0.51	0.47
RORAIMA	0.38	0.47	0.48	0.46	0.44
PARA	0.24	0.39	0.47	0.39	0.35
AMAPA	0.46	0.47	0.47	0.47	0.47
MARANHAO	0.13	0.20	0.22	0.19	0.18
PIAUI	0.10	0.16	0.19	0.16	0.15
CEARA	0.15	0.26	0.32	0.26	0.23
RIO GRANDE					
DO NORTE	0.16	0.35	0.67	0.41	0.33
PARAIBA	0.14	0.22	0.25	0.21	0.20
PERNAMBUCO	0.26	0.32	0.33	0.31	0.30
ALAGOAS	0.20	0.28	0.30	0.27	0.26
SERGIPE	0.22	0.42	0.59	0.45	0.38
BAHIA	0.23	0.34	0.39	0.34	0.31
MINAS GERAIS	0.33	0.53	0.63	0.53	0.48
ESPIRITO					
SANTO	0.35	0.55	0.65	0.55	0.50
RIO DE					
JANEIRO	0.81	0.74	0.74	0.76	0.76
PARANA	0.36	0.70	1.07	0.77	0.65
SANTA					
CATARINA	0.43	0.66	0.75	0.65	0.60
RIO GRANDE					
DO SUL	0.59	0.72	0.74	0.70	0.68
MATO GROSSO	0.32	0.54	0.68	0.55	0.49
GOIAS	0.24	0.42	0.55	0.44	0.38
DISTRITO					
FEDERAL	0.87	1.22	1.31	1.19	1.12

*relative income = state i PCI/Sao Paulo's PCI

TABLE 9 - BRAZIL - CROSS-TABULATION OF THE STATES ACCORDING TO THEIR GDP PER CAPITA RELATIVE TO THE NATIONAL AVERAGE - 1970 and 1995

		1995				
		Very Poor	Poor	Medium	Rich	Very Rich
1970	Very Poor	5	5	-	-	-
	Poor	-	3	5	-	-
	Medium	-	2	1	-	-
	Rich	-	-	1	-	-
	Very Rich	-	-	-	1	2

TABLE 10 - BRAZIL - INTERSTATE INCOME DISTRIBUTION - TRANSITION PROBABILITIES* (25 year transitions)

	Very Poor	Poor	Medium	Rich	Very Rich
Very Poor	0.500	0.500	0.000	0.000	0.000
Poor	0.000	0.375	0.625	0.000	0.000
Medium	0.000	0.667	0.333	0.000	0.000
Rich	0.000	0.000	1.000	0.000	0.000
Very Rich	0.000	0.000	0.000	0.333	0.667

* estimated from Table 9.

**TABLE 11 - BRAZIL - INTERSTATE INCOME DISTRIBUTION -
EQUILIBRIUM PROBABILITY VECTOR (estimated from Table10)**

	1970	1995	Long Run
Very Poor	0.40	0.20	-
Poor	0.32	0.40	0.52
Medium	0.12	0.28	0.48
Rich	0.04	0.04	-
Very Rich	0.12	0.08	-

**TABLE 12 - BRAZIL - INTERSTATE INCOME DISTRIBUTION -
TRANSITION PROBABILITIES (5 year transitions)**

	Very Poor	Poor	Below Average	Above Average	Rich	Very Rich
Very Poor	0.805	0.195	0.000	0.000	0.000	0.000
Poor	0.051	0.718	0.231	0.000	0.000	0.000
Below Average	0.053	0.263	0.474	0.210	0.000	0.000
Above Average	0.000	0.000	0.400	0.600	0.000	0.000
Rich	0.000	0.000	0.000	0.143	0.857	0.000
Very Rich	0.000	0.000	0.000	0.000	0.083	0.917

number of transitions with starting points in each income category: very poor = 41; poor = 39; below average = 19; above average = 7; rich = 7; very rich = 12

**TABLE 13 - BRAZIL - INTERSTATE INCOME DISTRIBUTION -
EQUILIBRIUM PROBABILITY VECTOR (estimated from Table 12)**

	1970	1995	Long Run
Very Poor	0.40	0.20	0.18
Poor	0.32	0.40	0.39
Below Average	0.12	0.16	0.28
Above Average	-	0.12	0.15
Rich	0.04	0.04	-
Very Rich	0.12	0.08	-

FIGURE 1

N.Cham. P/EPGE SPE F383c

Autor: Ferreira, Afonso Henrique Borges

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