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Abstract

The purpose of this paper is to deal with regional income convergence in Brazil taking a time series approach into account. Although a relatively large number of studies dealt with the subject of regional income inequality in Brazil no time series study, to our knowledge, has been performed so far. In order to test for the existence of evidences on income convergence endogenously determined break points are incorporated in the analysis. In particular, this investigation is based on a comparison of results provided by these tests. Our results indicate that there are signs of stochastic convergence of income at the macro regional level, with the exception of the North region. Convergence within the regions, that is, states converging to the income level in the region they belong to, is not homogeneous in the country. It is present for all states in the North, Mid-West and Southeast regions, but does not show up for all states in the Northeast (two exceptions out of nine states) and South (one exception out of three states) regions.

Key Words: Convergence, unit root tests, structural breaks.
JEL Classification: O18, R12.

1. Introduction

Brazil is well known for its high levels of regional inequality. Being a country with a large territory, that should not be surprising. The Northeast region of Brazil was home to 28% of Brazilian population in the year 2000 and produced only 13% of Brazilian GDP in the year 1998; the rich Southeast region presented 43% of Population and produced 58% of GDP. Per capita income in the Northeast was 54% below the national average, while in the Southeast it was 36% above that level in the same year. The poorest state, Piauí, in the Northeast region, had a per capita income level 5.6 times lower than the richest state, São Paulo, in the Southeast region[1]. The above relative

[1] See www.ibge.gov.br/ibge/estatistica/economia/contasregionais/, for information on regional income for Brazil, and http://www.ibge.gov.br/ibge/estatistica/populacao/censo2000/ for information on population.

figures are not too different from the situation half a century ago, since in 1947 the per capita income relation between Piauí and São Paulo states was 5 to 1.

Regional inequality in Brazil has attracted the attention of many authors over the years, including a more recent vintage of convergence studies. Ferreira and Diniz (1995), Schwartsman (1996), Ferreira and Ellery (1996), Zini (1998), Ferreira (2000) and Azzoni (2001) have developed traditional cross-section studies; Azzoni *et all* (2000) and Menezes and Azzoni (2000) have worked with panel data; Mossi, Aroca, Fernández and Azzoni (2002) have used intradistribution dynamics tools based on the construction of Markov transition matrices and stochastic kernels, for discrete and continuous analysis respectively; Magalhães, Hewings and Azzoni (2000) and Silveira-Neto and Azzoni (2002) have applied spatial econometric techniques to cross-section studies.

Traditional convergence studies deal with cross-sections of countries or regions within countries. It can be said that this sort of approach does not consider useful information present in the data. An improvement is to deal with panel data, in which the different conditions to steady state situations in distinct regions are taken into account. However, strong assumptions have to be made about parameter homogeneity. Given these difficulties, an alternative is the analysis of individual countries or regions over time, using separate time series regressions for each country. This is the approach followed in this paper. As in the other alternative methodologies, the time series approach is not immune to criticisms either[2]. One concern is about the quality and homogeneity of data over time, especially for low-income countries. Another problem is the availability of time series long enough to grant the use of the necessary regression techniques. If one wants to discern long-run effects of variables like inflation, a large number of observations is needed. Sometimes, short-run business cycle effects could drive apparent long-run correlations, and one needs long lags of the independent variables, thus jeopardizing the availability of degrees of freedom.

In the case of American states, Barro and Sala-I-Martin (1991, 1992) find cross-section support for conditional convergence, while Brown, Coulson and Engle (1990) find little time-series evidence supporting stochastic convergence. Carlino and Mills (1993) investigated both conditional (β) and stochastic convergence in the case of eight US regions, and had initial results for the latter that sort of matched the results of Brown, Coulson and Engle (1990). Using improved econometric techniques, allowing for the existence of an exogenously imposed trend break, they found evidence of stochastic convergence. Rather than imposing an exogenous trend break, Loewy and Papell (1996) worked with endogenously determined break points, strengthening Carlino and Mills (1993) results. They found evidence of stochastic convergence for seven out of eight American regions for at least one of the two models they estimate.

In the case of income inequality among Brazilian states, cross-section results in general present signs of absolute convergence, depending on the time span of the period analysed. All cross-section and panel studies indicate the presence of conditional, or β-convergence, indicating that states do converge over time to state-specific steady-state income levels. To our knowledge, no study yet has applied a time series approach to analyse regional income convergence in Brazil, a task that we set as our objective in this

[2] See Temple (1999) for a thoroughly analysis of the available approaches to study convergence.

paper. Next section includes the data and the econometric methodology to be employed in the paper. In section 3 we present and analyse the results. Finally, in section 4 we derive our conclusions.

2. Data and econometric methodology

2.1 The data base

In order to test for the existence of stochastic convergence among Brazilian states, we use data on per capita income for 20 states, covering the period 1947-1998. This data set consists of three different sources, as described in Azzoni (2001). Although nowadays Brazil has 27 states, we work with a set of only 20, maintaining the original administrative organization of the country as in 1947. Thus, states that were created during the period considered have been added to the states that were originated from.

We work with three different geographic levels. Initially we deal with the five official macro-regions of the country, and consider wether or not their relative income levels (per capita income level in the region related to national per capita income level) are converging. This will provide a broad view of the problem in the country. We then move to the second geographic level, in which we compare the relative income level of each state to the region it belongs to. Thirdly, we compare the relative income level of each state to the country, allowing for the identification of the states responsible for the results of convergence or divergence.

2.2. Econometrics

Since the seminal paper of Perron (1989), the importance of structural breaks for testing the null hypothesis of unit root has been noted. According to Perron (1989), the capacity of a unit root test to reject the null hypothesis decreases when a structural break is simply ignored. Then, the ability of the usual ADF and Phillips-Perron unit root tests to reject the null hypothesis when the stationary alternative hypothesis is true is indeed compromised. In fact, the power of these tests is diminished.

In order to provide an alternative unit root test, taking into account the circumstance that a structural break do exist, Perron (1989) admitted a modified version of the Dickey-Fuller unit root test, including dummy variables to deal with one exogenous break point. Later on, the literature on this issue evolved towards the development of test modifications allowing for break points endogenously determinate. The Zivot and Andrews (1992) minimum test is the endogenous procedure most widely used to select the break point when the t-statistic testing the null of a unit root is at its minimum value.

Evolving once more, the econometric literature on testing unit roots in the presence of a break point started questioning the possibility of the occurrence of a similar loss of power when ignoring two or more breaks in the time series. In fact, such a way of questioning is in accord to the previous evidence on the loss of power due to discard the influence of a structural break over the standard unit root tests. By extending the Zivot and Andrews (1992) test to two break points, Lumsdaine and Papell (1997) represents a recent contribution on this literature. Basically, the authors find more evidence against the null of a unit root hypothesis than Zivot and Andrews (1992), but less than Perron (1989), when the original 13 long-term annual macroeconomic time series tested by Nelson and Plosser (1982) are taken into account.

Though Lumsdaine and Papell (1997) indeed represents a remarkable contribution on developing the econometric methodology related to testing unit root in the presence of structural breaks, a common critical issue to minimum unit root tests is that they usually assume the inexistence of breaks under the null. Thus, these tests become invalid if at least one structural break occurs under the null. Indeed, the rejection of the null under these circumstances does not necessarily imply rejection of a unit root *de facto*. Instead, this rejection would imply discarding the hypothesis of a unit root without break. Perron (1989) had already called our attention, even for the exogenous version of testing the null hypothesis of a unit root with a break point developed by him at the end of the 80's. Additionally, Nunes *et al.* (1997) and Lee *et al.* (1998) provide evidence that assuming no structural break under the null hypothesis leads the tests to diverge, and consequently to spurious rejections when the data contains a break. In order to provide a solution to this problem, Lee and Strazicich (1999a) propose a two-break minimum LM test. This test is based on the Lagrange Multiplier (LM) unit root test, as suggested by Schimdt and Phillips (1992), and can also be seen as a natural extension of the one-break minimum LM test developed in Lee and Strazicich (1999b).

Overall, the two-break minimum LM test does not diverge as the presence of a break under the null is allowed or increases in size. Besides, such test is free of bias and spurious rejections. Lee and Strazicich (1999c) demonstrated that the two-break minimum LM test distribution is not affected, even accounting for break points under the null, because it is invariant to break point nuisance parameters. According to the same authors, the two-break minimum LM test is also robust to incorrect specifications of the number of breaks under the null.

Recently, some empirical evidence has raised the possibility of the existence of more than one break point in economic time series[3]. This is the case, for example, of GDP, *per capita* GDP and unemployment rate time series. In this sense, we recall three structural break models developed in Perron (1989): the crash model, CM, allows for a one-time change in level; the changing model considers a sudden change in slope of the trend function; and a third model that allows for changes in level and trend, the BT model. Since the third model incorporates the changing model, only the crash model and the break trend models are taken into account in this paper.

We consider two models, the crash model and the break trend model. Depending on the value of β[4], we have the following for the crash model[5]:

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[3] See, for example, BEN-DAVID, Lumsdaine and Papell (1999).

[4] $\beta=1$ for the null hypothesis and $\beta < 1$ for the alternative hypothesis.

[5] A similar representation can be associated to Break Trend Model.

$$H_0: \quad y_t = \mu_0 + d_1 B_{1t} + d_2 B_{2t} + y_{t-1} + v_t$$
$$H_{1:}: \quad y_t = \mu_1 + \gamma t + d_1^* D_{1t} + d_2^* D_{2t} + v_t \tag{1}$$

where v_t is a stationary error term, and $B_{jt} = 1$ for $t = T_{Bj} + 1$, $j = 1,2$, and zero otherwise. For the break trend model, D_{jt} terms are added to H_0 and DT_{jt}^* to H_1. Nesting both hypotheses in (1), it is possible to admit the two-break augmented unit root test equation, as follows:

$$y_t = \alpha_0 + \alpha_1 t + \alpha_2 B_{1t} + \alpha_3 B_{2t} + \alpha_4 D_{1t} + \alpha_5 D_{2t} + \phi y_{t-1} + \sum_{j=1}^{k} c_j \Delta y_{t-j} + e_t \tag{2}$$

Similarly, the two-break augmented minimum LM unit root test for the break trend model is given by the following representation, once the appropriate terms are introduced in the statistical model represented by (1):

$$y_t = \alpha_0 + \alpha_1 t + \alpha_2 B_{1t} + \alpha_3 B_{2t} + \alpha_4 D_{1t} + \alpha_5 D_{2t} + \alpha_6 DT_{1t} + \alpha_7 DT_{2t} + \phi y_{t-1} + \sum_{j=1}^{k} c_j \Delta y_{t-j} + e_t \tag{3}$$

Once a brief discussion on unit root tests with structural break points has been introduced, it is important to describe the econometric methodology to be followed from now on. Since the objective of this paper is to test for relative stochastic convergence in Brazilian *per capita* income time series, we start by testing the null hypothesis of a unit root in a standard ADF and PP framework. If the calculated results of these tests do not allow us to reject the null, we proceed by admitting the possibility for break points to be causing these results. Otherwise, the evidence on convergence is set at once.

Then, two unit root tests with break points, based on Lee and Strazicich (1999b) and Lee and Strazicich (1999c), are calculated: one-break and two-break minimum LM tests. For each of them, we admit two possibilities for the model set up: crash model and break trend models. As we already know, the standard unit root tests ignore the existence of break points in the time series, which leaves us with no other alternative than choosing unit root tests that take this into account. Finally, when choosing the magnitude of *k*, the lag length presented in all unit root tests, we adopt a procedure denoted by $k = \kappa(t - stat)$, suggested by both Campbell and Perron (1991) and Ng and Perron (1995). Such a procedure is clearly superior to one that simply sets the value of *k* equal to one.

3. Results

Estimating the model presented in the previous section lead to the results presented in Tables 1-3. Considering the five macro regions, it is clear in Table 1 that the ADF and PP unit root tests do not reject the null hypothesis for all time series involving relative per capita incomes. For all regions, in at least one model with break the null is rejected. The results thus indicate that stochastic convergence among Brazilian regions is present. Overall, the Break Trend Model (BT in the tables) present better results, constituting the best representation for testing for the existence of structural breaks in the series.

In the case of the North region, only in the Crash Model (CM in the tables) with two breaks the null is rejected, and only at 10% significance level. Thus, convergence of this region to Brazil's per capita income level is not empirically supported. This is due to the possible existence of inliers, i.e., elements that are related to abrupt governmental interventions in the economy, with no definite change in time series levels or trend along time. This is in fact the case in the region, for a free trade zone was established in the seventies and tax incentives to colonization and forestation projects were granted; these policies were later turned down. Moving on to the second geographical level (Table 2), we find out that states within the region are converging to the regional level of income. This indicates that the divergence of the region's level in relation to the nation's level in homogeneous within the region.

In the Mid-West region, the null is rejected only in the CM model with one break and with both models with two breaks. Thus, we find signs of stochastic convergence for the region, in relation the national income level. Considering the states within the region, evidence also favors convergence, even without breaks. The poor Northeast region is also converging, but only in the models with breaks. Within the region, most of the results are favorable towards accepting the stochastic relative convergence hypothesis, after accounting for two breaks in the series. However, PI, RN and BA do not follow that pattern. In the case of PI, the poorest state in the country, the lack of convergence is evident; in the case of RN, this conclusion is not so strong. Inequality moves against PI's per capita income, since the sign of the dummy variable of the second break is negative; the state moved from a positive path before the break into a negative path after it. In the case of BA, the largest economy in the region, the two-break BT test indicates a sharp decline in growth rates after the second break, in 1987. This can be related to the role of the chemical industry complex installed in the state in the mid-70s: it was responsible for the state growth, as registered by the significant dummy in the one-break BT test, and experienced difficulties in the mid-80s, that present until today.

The South region is also stochastically converging, but only with the two-break BT model. The sign of the dummy coefficient indicates that the region started to growth faster than the country after the second break. Within the region, convergence is achieved by all states, also with the two-break models. PR and SC are growing slower than the region after the break, and RS is growing faster.

The results indicate that the rich Southeast region is a classical example of income convergence. In this case, the best fit is found with the two-break BT model. The breaks are associated to important years in the Brazilian economic history: 1964, the year of the military coup and the beggining of the reorganization of the economy and of the so called Brazilian Miracle; and 1983, the last year of the deep recession of 1981-83, when the first signs of recovery started to show up. The dummy coefficient signs indicate that the region is growing at a slower path as compared to the nation. The same is true for the poor Northeast, after the most recent break, and that indicates a sign of divergence of that region to the national average. Within the region, convergence is present for all states, with MG and ES clearly growing faster than the region's average. For the bigger SP and RJ states, although convergence is present, CM and BT tests provide conflicting results. In the case of SP state, CM test indicates that this state is growing slower, while BT test indicates the contrary. In the case of RJ state, we find the contrary.

Next we move to the third geographical level of analysis that is each state in relation to the national average. Results shown in Table 3 reveal that 14 out of the 20 states present signs of convergence, 3 states show weak convergence, and in 5 cases there is no sign of convergence. Results are summarized below. It is interesting to point out that the two states of the North region are in the No Convergence situation, confirming the results of the regional analisys in previous paragraphs. It is also interesting that SP, the richest state, and PI, the poorest, are also in this situation. Thus, although for the majority of states stochastic convergence is present, the extremes of the income level distribution in the country are not affected.

Convergence: States with Respect to the Nation Per Capita Income

Convergence	Weak Convergence	No Convergence
AL BA CE MA	ES GO	AM PA PI
MT MG PB PR	PE	SC SP
RN RS RJ SE		

We can observe the direction of the movement by considering the signs of the dummy coefficients, as the chart below summarizes. It can be observed that, with the exception of MA, in the poor Northeast region, the states with positive signs are located in rich Southeast or South regions. On the other hand, most of the states with negative signs belong to the poorer regions. The important exceptions in the rich region are SP and RJ, states that together account for 46% of national GDP, both with negative signs. These states could be the responsibles for the general result of convergence observed. But instead of experimenting a spread of this effect to the poorest states in the country, it seems that this process is more one of spillovers within the rich region, benefiting neighbor states or region. That being the case, no important change in regional inequality in the country could be on the way.

Dummy Variable Signals: Convergence Direction

Positive	Negative	Uncertain
MA MG ES	AL BA CE PB	AM PA
PR RS	PE PI RN SE	SC
	SP MT GO	

4. Conclusions

In this paper we dealt with regional income convergence in Brazil taking a time series approach into account. Although a relatively large number of studies dealt with the subject of regional income inequality in Brazil no time series study, to our knowledge, has been performed so far. Our results indicate that there are signs of stochastic convergence of income at the macro regional level, with the exception of the North region. Convergence within the regions, that is, states converging to the income level in the region they belong to, is not homogeneous in the country. It is present for all states in the North, Mid-West and Southeast regions, but does not show up for all states in the Northeast (two exceptions out of nine states) and South (one exception out of three states) regions.

This study provided a new way to look at regional income inequality dynamics in Brazil. We were able to replicate the results of cross-section studies that indicate signs of absolute convergence among states, depending on the period considered. The inclusion of breaks in the series allowed for the consideration of different periods of convergence or divergence, identified in Azzoni (2001). Moreover, we were able to spot which regions and states are contributing to convergence and which ones are acting otherwise.

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Table 1 – Unit Root Tests for Relative *Per Capita* Income Between a Region and Brazil††

Regions	**ADF Test**	**PP Test**	**Model**	**Dummies**	**LS(1) Test**	**Breaks**	**Model**	**Dummies**	**LS(2) Test**	**Breaks**
Mid-West	-3.1770	-3.1545	CM	0.1609	-4.3137**	1989	CM	-0.0488	-4.4414**	1965
			BT	-0.0077	-4.2787	1973		0.1736*		1989
							BT	-0.2613***	-6.9853***	1978
								0.3045***		1988
North	-2.9489	-3.1468	CM	-0.1458***	-2.6804	1961	CM	-0.1249***	-3.6219*	1961
			BT	0.0637***	-4.3600	1978		0.1191***		1979
							BT	-0.0365**	-4.6949	1969
								0.0963***		1986
Northeast	-2.2403	-2.6814	CM	0.0442***	-6.6102***	1981	CM	0.0252	-6.0045***	1964
			BT	0.0095**	-6.7937**	1980		0.0382**		1981
							BT	0.0073	-6.6585***	1979
								-0.0223*		1982
South	-1.8526†	-2.9317	CM	0.1026***	-2.5343	1982	CM	0.0656	-3.1125	1973
			BT	0.0540***	-4.6563	1969		0.1008***		1982
							BT	-0.0588***	-6.1000**	1964
								0.1126***		1981
Southeast	-2.2018	-2.8211	CM	-0.0355**	-3.6238**	1983	CM	-0.0057	-3.6065**	1982
			BT	-0.0514***	-7.2305***	1982		-0.0432**		1984
							BT	0.0355***	-6.8929***	1964
								-0.0653***		1983

***Significant at 1% level; ** Significant at 5% level and * Significant at 10% level.

† In this case, the null hypothesis is not rejected even in first difference.

††CM accounts for Crash Model (Model A in Lee and Strazicich (1999)), and BT for Break Trending Model (Model C in Lee and Strazicich(1999)).

Table 2 – Unit Root Tests for Relative Per Capita Income Between a State and the Brazilian Region that Contains It††

States/Regions	ADF Test	PP Test	Model	Dummies	LS(1) Test	Breaks	Model	Dummies	LS(2) Test	Breaks
Mid-West										
Goiás (GO)	-3.7085**	-3.6101**	CM	-0.1076	-3.9061**	1983	CM	-0.1966*	-4.7372***	1977
			BT	-0.1122***	-5.4024**	1975		-0.0494		1983
							BT	0.1152***	-6.3337**	1961
								-0.1884***		1975
Mato Grosso (MT)	-3.6213**	-3.2318	CM	-0.0421	-3.7658**	1983	CM	-0.2521*	-4.6711***	1958
			BT	-0.0050	-3.7014	1985		0.4099**		1978
							BT	0.4141***	-5.9713**	1974
								-0.2685***		1981
North										
Amazonas (AM)	-3.0270	-3.4549	CM	0.1564**	-2.5667	1974	CM	0.1105	-4.7750***	1968
			BT	0.1251***	-3.2815	1973		0.1454**		1979
							BT	0.0262	-6.5984***	1968
								-0.0828***		1989
Pará (PA)	-3.0298	-3.5088**	CM	-0.0920**	-2.5197	1974	CM	-0.0623	-4.7352***	1968
			BT	-0.0792***	-3.3060	1973		-0.0910**		1979
							BT	-0.0420	-6.3320**	1968
								0.0410***		1989

State/Regions	ADF Test	PP Test	Model	Dummies	LS(1) Test	Breaks	Model	Dummies	LS(2)	Breaks
Northeast										
Alagoas (AL)	-4.0501**	-4.1059**	CM	0.1568*	-4.2957**	1973	CM	0.1826**	-4.5670***	1973
			BT	0.0564**	-4.7235	1968		0.1991**		1989
							BT	0.1163***	-6.0466**	1969
								0.1935***		1985
Bahia (BA)	-1.9426	-2.1285	CM	-0.1272**	-2.5859	1962	CM	-0.1272*	-2.5669	1962
			BT	0.0813***	-4.0463	1976		0.0639		1973
							BT	0.0490***	-6.5453***	1962
								-0.2070***		1987
Ceará (CE)	-2.2244	-4.9294***	CM	-0.1274*	-3.5940*	1973	CM	-0.0797	-5.7229***	1969
			BT	-0.0543***	-6.3634**	1969		0.0231		1990
							BT	-0.0663***	-6.8257***	1968
								0.0662**		1991
Maranhão (MA)	-3.7848**	-5.1751***	CM	-0.1839***	-2.4587	1988	CM	-0.0250	-5.9113***	1970
			BT	-0.0980***	-6.2170**	1970		-0.1219**		1973
							BT	-0.1106***	-7.3280***	1971
								0.0097		1977
Paraíba (PB)	-2.1357	-2.6954	CM	-0.1362***	-2.7372	1965	CM	-0.1299**	-3.1509	1965
			BT	-0.0959***	-5.1579	1974		-0.5542		1974
							BT	-0.1390***	-5.9415**	1964
								0.1826***		1988
Pernambuco	-2.5147	-3.0670	CM	-0.0260	-2.7961	1976	CM	-0.0316	-3.0600	1976
(PE)			BT	-0.1153***	-4.8827	1980		-0.1146**		1983
							BT	-0.1801***	-5.7071**	1979
								0.1241***		1988

State/Regions	ADF Test	PP Test	Model	Dummies	LS(1) Test	Breaks	Model	Dummies	LS(2) Test	Breaks
Northeast										
Piaui (PI)	-3.2117	-5.3377***	CM	-0.0090	-2.8679	1983	CM	0.0466	-2.9060	1966
			BT	0.0370**	-3.2465	1977		0.0471		1984
							BT	0.1545***	-5.0425	1959
								-0.0218		1983
Rio Grande do Norte (RN)	-2.8849	-3.3467*	CM	-0.2083**	-4.0462**	1969	CM	-0.2080**	-4.2523**	1969
			BT	-0.0191	-4.3773	1968		0.0780		1981
							BT	-0.0851***	-5.5481*	1968
								-0.2150***		1983
Sergipe (SE)	-2.6669	-5.5895***	CM	0.3531***	-6.6605***	1982	CM	0.0318	-7.1253***	1981
			BT	0.0061	-7.7816***	1982		0.1475		1992
							BT	0.1067***	-10.3365***	1976
								0.6781***		1987
South										
Paraná (PR)	-1.9124	-2.3381	CM	-0.1061**	-3.0919	1962	CM	-0.1025**	-3.5411*	1962
			BT	-0.0323*	-4.7136	1970		0.0673		1984
							BT	-0.1759***	-6.7110***	1970
								-0.0270***		1984
Rio Grande do Sul (RS)	-1.9409	-1.9719	CM	-0.1079***	-2.7645	1958	CM	-0.1172***	-2.8528	1958
			BT	-0.0559***	-3.1805	1975		0.0082		1964
							BT	-0.0382***	-6.0659**	1972
								0.0841***		1990
Santa Catarina (SC)	-1.8103†	-2.5261	CM	0.1035**	-2.0837	1965	CM	0.1015**	-2.4874	1965
			BT	0.0535***	-3.7443	1976		0.0743*		1975
							BT	0.0882***	-5.9712**	1966
								-0.0834***		1981

State/Regions	ADF Test	PP Test	Model	Dummies	LS(1) Test	Breaks	Model	Dummies	LS(2) Test	Breaks
Southeast										
Espírito Santo	-2.3459	-3.3243*	CM	0.0961**	-3.0540	1977	CM	0.1278***	-5.3839***	1977
(ES)			BT	0.0072	-4.3588	1982		0.1229***		1982
							BT	-0.0262	-6.0334**	1971
								-0.0143		1985
Minas Gerais	-2.4275†	-3.2530*	CM	0.0592**	-2.2379	1973	CM	0.0542*	-3.6784*	1973
(MG)			BT	0.0609***	-4.8057	1976		0.0987***		1980
							BT	-0.0075	-5.7873**	1969
								0.0402***		1979
Rio de Janeiro	-2.4167	-2.6173	CM	0.1796***	-2.9047	1989	CM	0.0872**	-4.0338**	1981
(RJ)			BT	-0.0478***	-6.6734***	1971		0.1545***		1989
							BT	-0.0387**	-6.1598**	1975
								-0.0757***		1983
São Paulo (SP)	-2.2494†	-2.6893	CM	-0.0635***	-2.8540	1980	CM	-0.0800***	-4.1162**	1980
			BT	-0.0513***	-5.4681*	1978		-0.0684***		1982
							BT	0.0114	-6.0020**	1967
								0.0716***		1979

***Significant at 1% level; ** Significant at 5% level and * Significant at 10% level.

† In this case, the null hypothesis is not rejected even in first difference.

††CM accounts for Crash Model (Model A in Lee and Strazicich (1999)), and BT for Break Trending Model (Model C in Lee and Strazicich(1999)).

Table 3 – Unit Root Test for Relative *Per Capita* Income Between a State and Brazil††

States	**ADF**	**PP**	**Model**	**Dummies**	**LS(1) Test**	**Breaks**	**Model**	**Dummies**	**LS(2) Test**	**Breaks**
Alagoas	-3.8998**	-4.3432***	CM	0.0424	-4.1091***	1976	CM	0.0952**	-4.4627**	1989
			BT	0.0045	-5.5143**	1989		-0.0593		1992
							BT	0.0897***	-6.0605**	1979
								-0.0905***		1986
Amazonas	-2.5715	-3.7551**	CM	0.0775	-2.0153	1974	CM	0.3059***	-3.1323	1979
			BT	0.2323***	-4.1458	1980		0.2831***		1984
							BT	-0.0727**	-4.8041	1969
								0.2162***		1980
Bahia	-2.2169†	-2.1275	CM	-0.0779***	-3.2424	1960	CM	-0.0502*	-3.0867	1962
			BT	0.0565***	-5.3734	1980		0.0242		1985
							BT	0.0942***	-6.2984**	1980
								-0.0405***		1989
Ceará	-2.2566	-4.0357**	CM	-0.0038	-4.5376***	1968	CM	0.0781*	-5.0334***	1961
			BT	-0.0650***	-5.1617	1981		-0.0380		1968
							BT	0.0532***	-6.0481**	1959
								-0.0310*		1969
Espírito Santo	-2.4934	-3.6771**	CM	0.1936***	-4.3235***	1982	CM	-0.0721	-5.1137***	1962
			BT	0.0045	-4.5966	1961		0.1412**		1977
							BT	0.0506**	-5.4897*	1975
								-0.0695**		1989
Goiás	-3.5866**	-4.0444**	CM	-0.1557**	-4.4161***	1982	CM	-0.0925	-4.6042***	1974
			BT	0.0093	-4.2129	1982		-0.1528**		1982
							BT	-0.1481***	-5.3381*	1979
								0.1346***		1985

States	ADF Test	PP Test	Model	Dummies	LS(1) Test	Breaks	Model	Dummies	LS(2) Test	Breaks
Maranhão	-2.2856	-4.0175**	CM	-0.0756***	-4.3246**	1973	CM	-0.0736***	-4.1048**	1973
				0.0128	-4.0589	1989		0.0525*		1986
							BT	-0.0223**	-5.8564**	1967
								0.0434***		1976
Mato Grosso	-3.5779**	-3.3137*	CM	-0.2408	-4.5978***	1983	CM	0.5907***	-4.6504***	1978
			BT	0.0054	-4.7939	1989		-0.2652		1983
							BT	0.2056***	-5.9977**	1974
								-0.0139		1983
Minas Gerais	-2.8785†	-3.7080**	CM BT	0.0902**	-2.9569	1973	CM	0.1140***	-4.6224***	1978
				0.0755***	-5.5112*	1976		0.2192***		1980
							BT	0.0035	-5.8384**	1969
								0.0094		1978
Pará	-2.2006†	-2.7957	CM	-0.0836*	-3.4492	1957	CM	0.0359	-3.8620**	1978
			BT	0.0359**	-4.3882	1988		0.0826*		1988
							BT	-0.0314**	-4.7150	1967
								0.0812***		1987
Paraíba	2.1583†	-2.4272	CM	-0.0948***	-4.2099**	1965	CM	-0.0963***	-4.3008**	1965
			BT	-0.0357***	-6.0646**	1973		-0.0490*		1979
							BT	0.1298***	-7.2266***	1960
								-0.0055		1975
Paraná	-1.6924	-2.2316	CM	0.2098***	-2.6670	1958	CM	0.2359***	-2.6774	1958
			BT	0.0387**	-5.5341*	1970		0.1671**		1973
							BT	-0.0565**	-6.1087**	1967
								0.2172***		1983

States	ADF Test	PP Test	Model	Dummies	LS(1) Test	Breaks	Model	Dummies	LS(2) Test	Breaks
Pernambuco	-2.3205	-2.3952	CM	0.0370**	-3.9444**	1990	CM	-0.0441*	-3.8936**	1969
			BT	-0.0275***	-4.6070	1966		-0.0364*		1973
							BT	0.0821***	-5.6564*	1961
								-0.0433***		1972
Piaui	-3.5422**	-5.5883***	CM	0.0509**	-2.9657	1961	CM	-0.0428*	-3.2000	1957
			BT	0.0068	-3.6008	1974		-0.0610***		1962
							BT	0.0500***	-5.0278	1957
								-0.0118*		1979
Rio Grande do Norte	-2.5063	-3.1679	CM	-0.0038	-4.5376**	1968	CM	-0.1332*	-3.9530**	1957
			BT	-0.0650***	-5.1617	1981		-0.0911		1979
							BT	-0.0578**	-6.0032**	1977
								-0.1291***		1983
Rio Grande do Sul	-3.3454	-4.0300**	CM	0.1158**	-3.3172	1979	CM	0.0311	-4.1655**	1968
			BT	0.0816***	-7.1462***	1969		0.0521		1972
							BT	0.0930***	-6.9144***	1969
								0.0257*		1987
Rio de Janeiro	-2.5396	-2.9380	CM	0.1688***	-3.6559*	1989	CM	-0.0907	-3.7221*	1972
			BT	-0.0749***	-5.3265*	1975		0.1728***		1989
							BT	-0.0846***	-5.7184**	1975
								-0.0750***		1983
Santa Catarina	-1.9089	-2.4976	CM	-0.0906**	-2.2606	1960	CM	-0.0990**	-2.3445	1960
			BT	0.0656***	-3.4126	1965		-0.0764		1962
							BT	0.1100***	-4.8517	1965
								0.1200***		1988

States	ADF Test	PP Test	Model	Dummies	LS(1) Test	Breaks	Model	Dummies	LS(2) Test	Breaks
São Paulo	-2.1484	-2.5593	CM	-0.0600	-2.1201	1976	CM	-0.0632	-2.5030	1973
			BT	-0.0572***	-4.4245	1974		-0.0841*		1988
							BT	0.0422**	-5.0509	1966
								-0.0736***		1982
Sergipe	-2.3280	-3.8317**	CM	-0.0746	-4.0191**	1992	CM	0.1995***	-5.4011***	1982
			BT	0.1178***	-5.5875*	1979		-0.1011*		1992
							BT	0.0760***	-6.9660***	1981
								-0.0866***		1990

*** Significant at 1% level; ** Significant at 5% level and * Significant at 10% level.

† In this case, the null hypothesis is not rejected even in first difference.

†† CM accounts for Crash Model (Model A in Lee and Strazicich (1999)), and BT for Break Trending Model (Model C in Lee and Strazicich(1999)).