HYSTERESIS VS. NAIRU AND CONVERGENCE VS. DIVERGENCE: THE BEHAVIOR OF REGIONAL UNEMPLOYMENT RATES IN BRAZIL*

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Abstract: This paper aims at analyzing the Brazilian regional unemployment behavior. Firstly, we use unit root tests with structural breaks to examine the hysteresis and NAIRU hypotheses in six Brazilian metropolitan areas - São Paulo, Rio de Janeiro, Belo Horizonte, Porto Alegre, Salvador and Recife - and in the country as a whole. Hysteresis is found in all series, except in Rio de Janeiro, which indicates a high persistence in the Brazilian regional unemployment. Secondly, we investigate whether the five metropolitan regions characterized by the hysteresis effect present stochastic convergence. The latter is not found in Porto Alegre's unemployment rate.

Keywords: Unemployment, Unit Root, NAIRU, Hysteresis, Convergence.

JEL classification: E24, R23, C22

Resumo: Este artigo analisa o comportamento do desemprego regional no Brasil. Primeiramente, nós utilizamos testes de raiz unitária com quebras estruturais para examinar as hipóteses de Histerese e NAIRU para seis regiões metropolitanas - São Paulo, Rio de Janeiro, Belo Horizonte, Porto Alegre, Salvador e Recife – e para o país com um todo. Histerese é encontrada em todas as séries, com exceção de Rio de Janeiro, o que indica um alto grau de persistência no desemprego regional do Brasil. Investigamos também se nas cinco regiões que apresentaram Histerese ocorre convergência estocástica. Tal convergência não é obtida apenas no caso de Porto Alegre.

Palavras-chave: Desemprego, Raiz Unitária, NAIRU, Histerese, Convergência.

Área 12 - Economia do Trabalho

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The author gratefully acknowledges CNPQ for financial support.

Introduction

There is no doubt unemployment has been a recurrent problem in several countries and it is a much bigger matter nowadays than it used to be some decades ago. As a result, it has been a major source of concern among policymakers and society as a whole. This is not different in Brazil and it even seems to have deeper roots in this country due to, among many other factors, a series of failed economic stabilization plans in the 1980s and in the beginning of the 1990s, a tight conduct of monetary policy towards the end of the 1990s, a lack of necessary investments in infrastructure, severe deficiencies in the Brazilian education system and demographic changes as well.

The beginning of the 1980s definitely represents a turning point in the Brazilian economy. The so-called "*economic miracle*" of the 1970s had come to an end with negative consequences to the GDP growth and to unemployment rates. This fact made the opening years of the 1980s very difficult for the country. And the following years were characterized an inconsistent recovery due to all the failed economic plans aimed at stabilizing the country's inflation. Consequently, in "lost decade", as some economists call the 1980s, there was a clear deterioration of the labor market with a widespread expansion of the underground economy in Brazil.

In the 1990s, the situation worsened and unemployment turned into one of the major distresses of the Brazilian society. The opening up of the economy in the beginning of the decade, which resulted in more foreign competition, as well as a deep recession in the period, aggravated the labor market, especially the industrial employment. As for the informal economy, it continued to expand and became even more perceptible. Right after the implementation of the *Real Plan*, in 1994, unemployment started to recover from the stagnation observed in the early years of the decade. The stabilization plan lowered the inflation rate and produced an economic stability, which caused a sharp increase in the purchase power, due to the end of the inflationary tax. Keeping a fixed exchange rate from the middle of 1994 up to the beginning of 1999, made the country highly dependent on the inflow of international capital and highly vulnerable to external shocks. The adoption of a flexible exchange rate, in 1999, gave the government more freedom to conduct the Brazilian monetary policy. However, in order to maintain inflation under control, the policymakers have been keeping high interest rates, which have been preventing the country from growing steadily and the unemployment rates from decreasing.

This overview was able to give a picture of the national unemployment in Brazil. Certainly, the problems explained above are found in every part of the country. However, Brazil has continental dimensions and significant differences in development among its major cities, local peculiarities are particularly important. In other words, analyzing unemployment from a national perspective is important but it is also crucial to study unemployment regionally. In fact, as argued by Clemente et al (2005), once the regional labor market is heterogeneous, a country's unemployment rate structure can be better understood if it is analyzed at a disaggregate level.

For that reason, the aim of this paper is to examine the unemployment rates of the six major Brazilian metropolitan areas - São Paulo, Rio de Janeiro, Belo Horizonte, Recife, Salvador e Porto Alegre – as well as national rate as a whole. In order to do this, we will perform two analyzes. The first one will contrast two main hypotheses related to the explanation of phenomenon: *i*) The *Non-accelerating-inflation Rate of Unemployment (NAIRU) Hypothesis*, which characterizes unemployment dynamics as a stationary process and, therefore, consistent with a stable inflation rate; *ii*) The *Hysteresis Hypothesis*, which is a result of questions made to the NAIRU and states that movements in unemployment might have a long-term persistence once it is affected permanently by cyclical fluctuations[1]. As usual, in order to confront both hypotheses for the aggregate and regional

[1] Phelps (1994) describes a third theory suggesting that most shocks to unemployment are temporary with occasional (but permanent) changes in the natural rate. As a result, the unemployment rate can be defined as a stationary process around a small number of (permanent) structural breaks (Lee, Strazicich & Tieslau, 2001). In other words, this can be seen as an extension of the NAIRU hypothesis as it accounts for the possibility of occasional changes in the long-run steady state unemployment rate. Therefore, the unemployment rate is stationary, as in the traditional version of NAIRU, but around a broken trend. In both cases, the rate does not present a prominent degree of persistence, as opposed to the

unemployment rates, we apply two types of unit root tests: the standard Augmented Dickey-Fuller (ADF) as well as endogenous one and two break LM tests proposed in Lee & Strazicich (1999, 2003). The second analysis is a long-run study of the convergence hypothesis for the regional unemployment series. For instance, Blanchard & Katz (1992) argue that when jobless individuals move to other areas to look for work there will be an adjustment of the labor market towards a long-run equilibrium and, consequently, there will be convergence of regional unemployment rates. The methodology employed is a straightforward extension to the unemployment case of the stochastic convergence test put forward by Carlino & Mills (1993).

Our results show that the hysteresis phenomenon occurs in all regions, except in Rio de Janeiro, and in Brazil as a whole. This is an indication of high persistence in the Brazilian unemployment series. As for the convergence tests, our findings suggest that São Paulo, Belo Horizonte, Salvador and Recife present stochastic convergence, which implies that Porto Alegre's unemployment rate differential remains in the long run. But the non-convergent cities have a lower unemployment mean, i.e., the others are converging to a higher level of unemployment.

The remainder of the paper is organized as follows. Section 2 revises the literature on the NAIRU versus hysteresis hypotheses, whilst section 3 looks at the literature on convergence. Section 4 presents the data, the descriptive analysis and the econometric methodology as well. Section 5 describes the results and section 6 concludes.

2. Nairu versus Hysteresis

Friedman (1968) and Phelps (1968) were the first authors to work with the proposal of a Natural Rate Hypothesis. They presented reasons to support the idea that the behavior of real variables was solely determined by themselves and they could not be affected permanently by nominal variables, such as inflation. Consequently, the long-run unemployment would converge to its natural rate.

In the tradeoff case between inflation and unemployment, Friedman's as well as Phelps' argumentations were that, eventually, any sort of permanent expansionary policy could modify the setting method of wages and prices. Therefore, the reasons which made real wage and unemployment prevail in a world without inflation were similar to those which would prevail in an environment with inflation. As a result, wages would take into account expansionary policies that would, eventually, occur (Romer, 2001).

The NAIRU hypothesis began to be questioned in the 1970s and 1980s due to constant movements observed in the unemployment rates around the world. This resulted in the Hysteresis hypothesis, which had one of its first statements in Blanchard & Summers (1986), who were concerned about the phenomenon in Europe. The authors argued that anything which raised the actual rate of unemployment for a sufficient length of time - a sustained increase in real interest rates induced by monetary policy, for instance - was likely to affect both the actual and the natural rate of unemployment due to insiders' bargain power.[2] And this power will define whether or not they will set the wage sufficiently high. The greater it is, the higher the wage setting will be and, eventually, the higher the risk of losing a job.

Uncommonly large shocks to labor demand can make insiders lose their jobs. As a consequence, Blanchard & Summers (1986) argued that variations in unemployment could make changes in the number of insiders and, therefore, have an effect on future wage-setting and unemployment. For example, unemployed (hired) workers lose (gain) bargaining power in wage-setting. Therefore, deterioration in labor demand might increase unemployment rates and, consequently, lessen the quantity of insiders whereas a rise in employment is likely to increase the quantity of insiders.

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hysteresis hypothesis. For that reason, in this paper we will refer to the NAIRU theory even in the case of structural changes in the unemployment rate.

[2] Insiders are those workers who have some connection with the firm at the time of the bargaining, and whose interest is taken into account in the contract.

The authors' model implies that insiders are able to determine wages in the whole labor market and, consequently, aggregate employment will follow a random walk with a drift. Therefore, hysteresis in unemployment means that the one-time shock to labor demand has a long-lasting effect on employment (Romer, 2001).

But there are two other important sources of hysteresis that should be taken into consideration. The first one is the deterioration of skills. It means that unemployed workers are not able to keep updated on their skills and so, their human capital might deteriorate or even disappear. Consequently, it will be more difficult for them to find work when demand is recovered. The second source of hysteresis is labor-force attachment. Individuals who are unemployed for long periods may adjust their standard of living to a lower level and/or may even get used to the joblessness situation. As a result, there might be a permanent decrease in labor supply when demand returns to normal (Romer, 2001).

As the hysteresis theory evolved, several articles started to empirically test it and compare the results with the NAIRU hypothesis.[3] For instance, Neudorfer, Pichelmann & Wagner (1990) examine the hysteresis phenomenon for Austria and Jaeger & Parkinson (1994) analyze the unemployment rates in the U.K., the USA, Canada and Germany. Both works use the standard ADF unit root test and they do not reject the null hypothesis of a unit root and, consequently, the hysteresis theory.

However, since Perron (1989), it is well known that ADF tests can fail to reject a false unit root due to misspecification of the deterministic trend. In fact, Perron (1989, 1997) and Zivot & Andrews (1992) extend the ADF test considering an exogenous and an endogenous break in an attempt to avoid this problem. Mitchell (1993) performs Perron's unit root tests and his results also support the unit root hypothesis and hysteresis for several OECD nations. Arrufat et alli. (1999) perform unit root tests with structural breaks, based on Zivot & Andrews' methodology, for the Argentine rate of unemployment as well as for 24 urban locations. Their results reject the unit root null hypothesis for 15 locations, including the nation-wide rate of unemployment.[4] Using Perron's (1997) test, León-Ledesma & McAdam (2004) analyze the transition process of CEECs economies and conclude that the evidence in favor of the hysteresis hypothesis weakens after controlling for structural breaks.[5] Lumsdaine & Papell (1997) extend Zivot & Andrews's test allowing for two breaks in level and trend. Arestis & Mariscal (1999) apply this methodology for 26 OECD countries and show a rejection of the hysteresis hypothesis for the majority of the nations. Clemente et al (2005) discuss the unemployment structure of the US states taking into account structural breaks. The article rejects the unit root null hypothesis for 80% of the states and also rejects the hysteresis hypothesis for the American aggregate unemployment.

Finally, Song & Wu (1998) analyze 15 OECD countries using Levin & Lee's (1992) panel unit root test, finding strong evidence against the hysteresis hypothesis. Lee, Strazicich & Tieslau (2001) study the validity of the hysteresis hypothesis with unemployment rate data from 17 OECD countries. The authors employ a panel LM unit root test that allows for heterogeneous structural change and find a strong rejection of the hypothesis. Camarero & Tamarit (2004) study a panel of

[3] To the best of our knowledge there are no articles comparing hysteresis and NAIRU hypothesis for the Brazilian case. Some works attempt only to find the Brazilian NAIRU. For instance, Portugal & Madalozzo (2000) use two different unemployment rate series, which belong to the *National Bureau of Geography and Statistics* (IBGE) and the *Worker's Union Bureau of Statistics* (DIEESE), for the period between 1982:3 and 1997:3. For the IBGE's data they find a NAIRU varying from 3.05% in the third quarter of 1986 to 9.21% in the fourth quarter of 1989. The use of DIEESE's series data results in a constant NAIRU of 10.3%. The authors also suggest that the actual rate of unemployment converges to the *NAIRU* in the period 995.3/1997.3, reaching its long-term equilibrium level at some point during that period. Lima (2000) also estimates the Brazilian NAIRU using IBGE's data(1982.1/1999.3). The author works with ARCH residuals and Markov-switching regime and concludes that the estimates of the NAIRU are very imprecise. These two works show that hysteresis hypothesis may be the case for the Brazilian data once no result is robust enough to confirm the NAIRU hypothesis.

[4] For the US case, Staiger, Stock & Watson (1997) suggest that the evidence doesn't support the hysteresis hypothesis. They argue that, although there have been some shifts, they have been minor over the last 3 decades.

[5] The authors also apply panel unit root tests and, although the auto-regressive roots are found to be of order 0.9, the results strongly reject the null of nonstationarity at the 1% level.

19 OECD countries and, for that, apply a sequential procedure based on two multivariate ADF test-type panel unit root tests in a SURE framework. Their results strongly reject the joint null of hysteresis.

3. Regional Unemployment and Convergence

Regardless of the integration order of the series, it is imperative to study whether unemployment rates among different regions have got something in common which attracts them in the long run. Indeed, convergence matters especially when the series are integrated. If the hysteresis hypothesis is the case, which indicates that there is no mean reversion in the series, they might also present some convergence pattern. For that reason, looking for disparities amongst regional unemployment rates, as well as seeing if there is any process of convergence amongst them, is a crucial investigation for Brazil once, as mentioned previously, it has got continental dimensions and several peculiarities between regions.

Theoretically, the importance of studying regional unemployment is well discussed in Marston (1985), who gives a clear explanation of the so-called compensation theory. This theory predicts that, in equilibrium, all individuals have the same utility level, and so areas more attractive could have a larger unemployment rate. The author applies his theory to the American case and his findings show that disturbances to the steady-state relationship among unemployment rates of important US metropolitan regions are likely to disappear because of mobility within a particular year.

Blanchard & Katz (1992) go one step further and say that when jobless individuals move to other areas to look for work there is an adjustment of the labor market towards a long-run equilibrium, i.e., there is convergence of regional unemployment rates. The authors analyze the dynamics of the American regional unemployment but don't find a strong indication for stationarity of the rates and attribute the weak results to the tests used. Therefore, while Marston (1985) suggests that unemployment differentials may not disappear in the long run, Blanchard & Katz (1992) state the opposite.

In spite of this difference, Poirine (1994) analyzes many small island economies and concludes that some of them have massive emigration and almost no unemployment while others have no emigration (or even immigration) and sometimes exhibit high unemployment. In fact, the author develops a four-sector economic model to explain such differences in migration behavior and unemployment rates, for islands with unlimited legal emigration outlets.

Jimeno & Bentolila (1998) extend the Blanchard & Katz's (1992) model in order to study the sources of persistence of regional relative unemployment – the deviation of the regional rate from the national – in Spain. They show that regional wages, relative unemployment and participation rates are very persistent in Spain, while employment growth rates are not.

Bayer & Juessen (2004) analyze the West German regional unemployment rates and also apply unit-root tests that allow for structural breaks. For three of the ten federal states, and for Germany as a whole, the null hypothesis of a random walk cannot be rejected. To test the convergence hypothesis, the authors apply unit root tests on the country's relative unemployment rate – the difference between states' rates and the aggregate figure – and find a strong evidence for convergence as well as a very high speed of the phenomenon.

As for the analysis of provincial unemployment in Brazil, Corseuil, Gonzaga & Issler (1999) investigate short run and long run unemployment movements across six metropolitan regions in Brazil (São Paulo, Rio de Janeiro, Belo Horizonte, Recife, Salvador, Porto Alegre). The authors find evidence that, with an exception for the Recife metro area, aggregate components are relevant for regional unemployment rates. They also categorize short and long run co-movements among the other five unemployment rates and the national figure. In addition to that, the article makes a decomposition of the series in permanent and temporary elements. The former follows very closely the respective unemployment rates, which is an indication of high persistence of the disturbances that influence the regional rates.

Oliveira & Carneiro (2001) also look for a possibility to establish a long-run relationship between states and national rates of unemployment. Two econometric techniques are used: The Engle-Granger co-integration analysis and the Unrestricted Error Correction Model. Their findings suggest that, in general, the States and the nation-wide unemployment rates have similar dynamics, but with permanent differences in the long run. If we suppose that the States have different levels of attractiveness, this result is consistent with Marston's (1985) prediction that, in equilibrium, all individuals have the same utility level, and so more attractive areas could have a larger unemployment rate.

4. Econometric Methodology

4.1 Data

The data used in the analysis are the seasonally adjusted monthly rates of open unemployment[6] for the six major Brazilian metropolitan areas (São Paulo, Rio de Janeiro, Belo Horizonte, Recife, Salvador and Porto Alegre) and the nation-wide rate as well. São Paulo, Rio de Janeiro and Belo Horizonte are all located in the Southeast of the country. Recife and Salvador are both located in the Northeast whereas Porto Alegre belongs to the South.

The source of the data is the Monthly Employment Survey (*Pesquisa Mensal de Emprego*) from the National Bureau of Geography and Statistics (*IBGE*), from 1981:01 to 2002:12, totaling 264 observations.[7] It should be remarked that the aggregate rate of unemployment for Brazil corresponds to the weighted average of the regional rates, relative to the economically active population of each metropolitan region.

Figure 1 reports the evolution of regional unemployment rates for Brazil, Greater São Paulo (SP) and Greater Rio de Janeiro (RJ). Firstly, one can notice the presence of two peaks in the beginning of the 1980s, both because of sharp economic recessions. Also, it can be seen that the dispersion of unemployment rates has increased considerably since the beginning of the 1990s, and this is due primarily, to tight economic policies, especially monetary policy, as mentioned by Blanchard & Summers (1987). As a result of these two facts, the graphic analysis suggests the existence of two structural breaks: the first one in the beginning of the 1980's and the second one after the *Real* stabilization plan. It is also worth mentioning a close similarity between the unemployment rates of São Paulo and Brazil, which may be caused by the fact that the former is Brazil's most populated metropolitan region. As for Greater Rio de Janeiro, the vertical axis shows a lower unemployment rate series, which can be a first indication of a distinct behavior when compared to the other cities.

[Insert Figure 1]

The dynamics of the regional unemployment rates for Greater Belo Horizonte (BH) and Greater Porto Alegre (PA) is plotted in Figure 2, together with the national rate. Again, the evolution of the series is quite analogous to the previous figure, with a high level of unemployment observed in the beginning and in the end of the sample. As before, this pattern suggests the existence of two structural breaks: early years of the 1980's and after the *Real* Plan.

[Insert Figure 2]

[6] IBGE defines open unemployment as members of the workforce older than 15 who searched for work during a week and did not find one.

[7] Two reminders: *i*) In June and July/1992, there were no data available for the metropolitan regions once the survey was not performed due to workers' strike. In these cases, the procedure adopted was a linear interpolation. *ii*) IBGE did not stop releasing unemployment data after 2002:12. However, there was an important change in methodology, which prevents us from going beyond that period. The main methodological changes followed recommendations of the International Labor Organization and refer to the geographic coverage, population at an active age, collection instruments, expansion of the sample, etc.

Figure 3 reports the evolution of regional unemployment rates for Greater Salvador, Greater Recife and, once more, the Brazilian unemployment rate. Despite following the same progression of the preceding figures, there are some details related to Salvador and Recife that need to be mentioned. Unlike the other series, the two metropolitan areas present a peak in 1992/1993, which is more prominent for Greater Recife. This could be an explanation for the results reported by Corseuil, Gonzaga & Issler (1999). In their article the authors suggest that, for the Recife metropolitan area, aggregate components are not too relevant. In fact, it is not apparent whether the two-break pattern described for the other regions and, for Brazil as a whole, applies to Recife.

[Insert Figure 3]

Apart from a graphic analysis, it is important to study whether there can be persistent differences among regional unemployment rates in Brazil. The descriptive statistics and the correlation analysis, depicted in Tables 1 and 2, may be useful to this end. We notice that Recife presents the highest mean, followed by Salvador, which has the second highest standard deviation. However, this doesn't seem to be a structural factor underlying the series. It appears that these high values are more related to isolated periods within the sample. For Recife, this period goes form 1992 to 1994 whereas for Salvador the year 2000 may be the case. Also, as opposed to the other regions, both cities do not present unemployment rates below 3,4%. In addition to that, one can notice that Salvador, Rio de Janeiro and Recife have, respectively, the highest maximum values.

Table 2 shows that Greater São Paulo has the highest correlation with Brazil, which is expected once it is Brazil's biggest metropolitan region. It is also clear that Rio has the lowest mean, which indicates something very peculiar, and that Greater Recife has the lowest correlation, followed by Greater Salvador, as pointed out by Corseuil, Gonzaga & Issler (1999). Again, the reason for such finding is because Recife had very high unemployment rates between 1992 and 1994 and Salvador had a similar pattern around year 2000.

Therefore, both the descriptive and correlation analyses provide support that the regional behavior of the unemployment in Brazil needs to be assessed carefully and this evaluation will unquestionably lead to a better understanding of the problem when compared to the examination provided by the study of the national unemployment rate.

[Insert Table 1]

[Insert Table 2]

4.2 NAIRU versus hysteresis

To confront NAIRU and Hysteresis, we follow Neudorfer, Pichelmann & Wagner (1990) and Jaeger & Parkinson (1994), i.e., we apply the ADF test to the aggregate as well as the regional unemployment series as a benchmark test. The following specification is used:

$$\Delta U_t = \mu + \beta t + \alpha U_{t-1} + \sum_{j=1}^{k} c_j \Delta U_{t-j} + \varepsilon_t \qquad (1)$$

where U_t is the unemployment rate, μ and t are the constant term and the linear trend, respectively.[8]

However, our data seem to exhibit structural changes and the ADF test can fail to reject a false unit root due to misspecification of the deterministic trend. As mentioned, in attempt to overcome this trouble, Perron (1989, 1997), Zivot & Andrews (1992) and Lumsdaine & Papell (1997) extended the ADF test considering exogenous and endogenous break(s) in its trend function. Nevertheless, these extensions have some drawbacks once they derive their critical values assuming no break(s) under the unit root null hypothesis. And this leads to a spurious rejection of the null hypothesis in the presence of a unit root with breaks, as discussed by Lee & Strazicich (1999,

[8] Following Ng & Perron (1995), we define a *k-max* to choose *k* and use the (approximate) 10% value of the asymptotic normal distribution, 1.645, to assess the significance of the last lag.

2003). In order to avoid such problems, the authors propose an endogenous LM unit root test with one and two-break, whose properties are unaffected by breaks under the null, in contrast to the ADF-type tests.

Therefore, in addition to using the ADF test, we apply this LM test. The methodology is the following[9,10]: according to the LM (score) principle, a unit root test statistic can be obtained from the following regression:

$$\Delta U_t = d'\Delta Z_t + \phi \tilde{S}_{t-1} + \sum_{i=1}^{k} \gamma_i \Delta \tilde{S}_{t-i} + \varepsilon_t \qquad (2)$$

where:

i) $\Delta \tilde{S}_{t-i}$, $i = 1,...,k$, terms are included as necessary to correct for serial correlation;[11]

ii) $\tilde{S}_t$ is a de-trended series such that:

$$\tilde{S}_t = y_t - \tilde{\psi}_x - Z_t \tilde{\delta}, \quad t = 2,...,T \qquad (3)$$

iii) $\tilde{\delta}$ is a vector of coefficients in the regression of Δy_t on ΔZ_t;

iv) $\tilde{\psi}_x = y_1 - Z_1 \tilde{\delta}$, where Z_t is a vector of exogenous variables defined by the data generating process;

v) y_1 and Z_1 are the first observations of y_t and Z_t, respectively;

vi) Considering 2 changes in level and trend Z_t is described by $\left[1, t, D_{1t}, D_{2t}, DT^*_{1t}, DT^*_{2t}\right]'$, where: *a*) $D_{jt} = 1$ for $t \geq T_{Bj} + 1$, $j = 1,2$, and zero otherwise; *b*) $DT^*_{jt} = t$ for $t \geq T_{Bj} + 1$, $j = 1, 2$, and zero otherwise; *c*) T_{Bj} stands for the time period of the breaks. Note that the test regression (2) involves ΔZ_t instead of Z_t so that ΔZ_t becomes $\left[1, B_{1t}, B_{2t}, D_{1t}, D_{2t}\right]'$, where $B_{jt} = \Delta D_{jt}$ and $D_{jt} = \Delta DT^*_{jt}, j = 1,2$.

The unit root null hypothesis is described in equation (2) by $\phi = 0$ and the test statistic is defined is given by: $\tilde{\rho} = T \cdot \tilde{\phi}$,

$$\tilde{\tau} = \text{t-statistic for the null hypothesis } \phi = 0 \qquad (4)$$

To endogenously determine the location of the two break points T_{Bj} in each time series, we use a similar procedure used in the "minimum LM test", that is, a grid search is utilized to determine the break where the t-test statistic is minimized:

$$LM_\tau = Inf\, \tilde{\tau}(\lambda) \qquad (5)$$

There is a repeated procedure at each combination of break points $(\lambda_j = T_{Bj}/T, j = 1,2)$ over the time interval [.1*T*,.9*T*] where T is the sample size. As shown in Lee & Strazicich (2003), critical values for this model depend on the location of breaks ($\lambda_j = T_{Bj}/T, j = 1,2$). As a result, we utilize critical values that correspond to the location of the breaks.

4.3 Convergence

As for the convergence subject, this paper makes use of the stochastic convergence test, developed by Carlino & Mills (1993), and studies the progression of discrepancies in unemployment rates of the country's six major metropolitan areas.

Carlino & Mills' (1993) approach, which was originally developed to analyze per capita income convergence among U.S. regions, is based on the following idea: if per capita income of different regions is converging, then their income should not diverge arbitrarily and, consequently,

[9] Due to space limitations we present the two-break case. For the one break test methodology the reader can refer to Lee & Strazicich (1999).

[10] We decided not to apply panel tests because we use only six cross-section units.

[11] See footnote 3.

the relative income – the (*ln*) ratio of region *"i"* income and the mean income – should be stationary. Therefore, this argument can be looked at by a unit root test.[12]

For that reason, the aim is to extend the authors' approach and apply it to the relative unemployment of those regions that present hysteresis. Thus, the first step consists in defining the relative unemployment rate of region *i*, u_{it}, as the (*ln*) ratio of the unemployment rate U_i and the average unemployment rate of the regions, such that,

$$u_{it} = \ln \frac{U_{it}}{\left(\sum_{i=1}^{I} U_{it} \Big/ I \right)} \qquad (6)$$

Stochastic convergence is defined as the (*ln*) of the unemployment rate from one region relative to the region's average, u_{it}, being stationary. In other words, under stochastic convergence, shocks to a region's relative unemployment are temporary. For each area, we examine the null hypothesis that unemployment is diverging by testing for a unit root in u_{it}. Failure to reject the unit root's null hypothesis indicates evidence against stochastic convergence, which is examined using the same unit root procedure applied to the NAIRU and hysteresis hypotheses, i.e., ADF tests and Lee & Strazicich's (1999, 2003) framework.

5. Econometric Results

5.1 NAIRU versus hysteresis results

The benchmark ADF test was started with a maximum length of *k* (*kmax)* equal to 8, as Table 3 reports. At a 5% level of significance, the unit root null hypothesis is not rejected for Brazil as a whole and for all regions, except Rio de Janeiro. In other words, the hysteresis phenomenon is found in the national series and also in 5 metropolitan areas. This distinct behavior of Rio de Janeiro area had been noticed in the graphic analysis, which showed that that the region had lower unemployment rates than the others after 1990. As for Greater Recife, the null hypothesis is also rejected at a 10% level of significance, but this needs to be looked at more carefully.

[Insert Table 3]

In order to double check the above results, we perform the LM unit root test for the series, considering the unknown structural break(s). We implement Strazicich's et. alli. (2004) procedure, viz. we estimate the test equation including two break dates and, if the level (B_{jt}) and the trend (D_{jt}) dummies coefficients are not significant at 10% for one break date, we re-estimate the test equation with just one break date. The results are reported on Table 4. Only Salvador presents one break and the unit root null hypothesis is rejected for Rio de Janeiro, at 5% and 10%.

[Insert Table 4]

These results confirm the hypothesis of full hysteresis for the other series, which means that not only do shocks observed in the Brazilian economy cause deviations around a deterministic trend but they also affect the national unemployment rate employment permanently. This influence is then spread to the regional unemployment rates and only Rio de Janeiro manages to deter such pressure. In fact, as the Rio de Janeiro's result shows how important the disaggregate analysis is. As the aggregate series is a weighted average of the regional rates, if the former contains a unit root, it does not mean that all local series are integrated.

There are several anecdotal evidences for Rio's peculiarity: *i*) its population grows slower than the other metropolitan areas; *ii*) it seems that youngsters have opted, more than the other

[12] While Carlino & Mills apply unit root tests with an exogenous break, Loewy & Papell (1996), Tomljanovich & Vogelsang (2002) and Strazicich et al. (2004) refine their approach using endogenous break unit root tests.

regions, to qualify themselves prior to getting into the labor market; *iii*) public sector jobs have been created in the three levels of government (Federal, State, Municipal).

[Insert Figure 4]

For 1991 and 2000, The Brazilian Human Development Report reports some important information (Table 5) about the population of the regions we are analyzing. Firstly, it is clear that in the period 1991-2000 Rio de Janeiro had the lowest rate of population growth amongst the 6 greater areas. Besides, with the exception of Porto Alegre, there is evidence that people aged between 18 and 24 have more years of formal education in Rio de Janeiro, which confirms our hypothesis that youngsters have opted, more than the other regions, to qualify themselves prior to getting into the labor market. As for Porto Alegre, it presents the highest level of human capital for people aged between 18 and 24. But its population growth is higher than Rio's and it has got a lower proportion of retired people (those over 65).

[Insert Table 5]

Lastly, to visualize our empirical findings, we superimpose the break points identified by the two-break tests and plot the unemployment series for the series (Figure 4). We perform a trend estimation, via ordinary least squares, in order to connect the break points. There is clear evidence that, in general, the series have two significant shifts in unemployment. For all the unemployment rates containing two breaks, with the exception of one only, the first break falls into the period of 1985/March – 1986/May. As for the second break, it falls into the period of 1997/October – 1999/February, for all series, except one. Table 4 shows that the exception is Greater Recife, as it is also shown in Figure 4. An economic interpretation for the breaks might be the following. There were two periods of recession in the past decades: 1981-83 and 1990-92. The recovery from the first recession can be the explanation for the first break. After this downturn, there was a reduction in unemployment in the following years, i.e., they went from higher to lower levels and the break happened around 1986. The Recife metro area didn't deal well with the second recession and this is the reason why its two breaks are located in the beginning and in the end of the downturn. The second break coincides with the fixed exchange rate crisis around 1998.

5.2 Convergence results

We study the occurrence of stochastic convergence by means of the ADF test and report them on Table 6. We notice that the unit root null hypothesis is rejected in three cases, at a level of 10% of significance level: São Paulo, Porto Alegre and Salvador. This is a first indication of evidence in favor of a stochastic convergence.

[Insert Table 6]

Again, the LM unit root break test is implemented following Strazicich's et. alli. (2004) procedure described previously. This approach is particularly important in this context because we observed, in the previous section, that the unemployment series have similar break dates. Thus, some of these breaks may disappear when we build the relative unemployment series. In fact, as Table 7 shows, São Paulo and Porto Alegre present two breaks whereas the other cities present no more than one. Furthermore, the stochastic convergence hypothesis is rejected only for Porto Alegre, at 5% and 10% significance levels.

A plausible explanation for this peculiar behavior found in Porto Alegre's unemployment rate might be due to the fact that jobless workers from other regions, because of distance and regional factors, do not tend to migrate to Porto Alegre in order to find work. In other words, the city does not attract many job seekers and, as a result, it has lower levels of unemployment, as suggested by the compensation theory. This characteristic helps us to notice that Porto Alegre

follows its own pattern and it is not influenced much by the other regions. On the other hand, the other metropolitan regions seem be more linked and the distance between them is not a problem. This is clearly seen by the frequent migration of northeast people to the southeast of Brazil, which could be an explanation for the convergence of the series. This is also in line with the regional unemployment literature discussed previously.

[Insert Table 7]

Table 8 gives us more information on the matter discussed above. By looking at the population census (1991 and 2000) we are able to compare the migration flow of the Brazilian population at the beginning and end of the 1990s. As reported on Table 8, in 1991, 3,225,929 people lived in regions distinct from those they were living in 1986 and, in 2000, this amounted to 3,363,546, which represented an increase of 4.3%. As we are analyzing cities from the Southeast, Northeast and South regions, we can concentrate only on them. Comparing the beginning and the end of the decade, it is clear that people from the Northeast region, where Salvador and Recife are located, emigrate more than the others. The emigration in the second half of the decade was 4.2% greater than that observed in the first half. The migration to the Northeast increased about 36% in the decade and a considerable part of the flow is due to migrants returning from the Southeast region. The South region is the only one that showed an increase in the annual growth rate of the total population. Between the periods of 1980/1991 and 1991/2000, the rate went from 1.38% to 1.43%. Such increase was mainly because of migration. The immigration raised 16% whilst the emigration decreased 26%. Besides, the migration to the Southeast reduced 27%. These confirm our findings.

[Insert Table 8]

In order to visualize our empirical findings we superimpose the break points identified by the two-break tests and plot the unemployment rates for the all the series, which are displayed in Figure 5. The break points are connected by trend estimation via ordinary least squares. For Belo Horizonte, Salvador and Recife, we notice that the one- break trend is able to replicate the relative unemployment behavior. On the other hand, São Paulo and Porto Alegre demand the two-break trend function.

[Insert Figure 5]

6. Conclusion

The purpose of the paper was twofold. Firstly, we tested the hysteresis effect in unemployment for the six major metropolitan areas in Brazil and compared them with the nationwide unemployment rate. In order to do this, we applied a standard unit root test and also unit root tests that allowed for breaks in the trend function of the rates of unemployment. Our results showed that the unit root null hypothesis could not be rejected for all series, except for Rio de Janeiro. Therefore, the hysteresis hypothesis was able to explain more properly the behavior of unemployment as opposed to the NAIRU theory.

Secondly, as there was clear evidence of high persistence in the unemployment behavior of the most important cities in Brazil, we investigated the occurrence of stochastic convergence among the five metropolitan regions characterized by the hysteresis effect. Our findings suggested that only Porto Alegre did not exhibit convergence, which was an indication that this region had some peculiarities not found in the rest of the country.

As a result, our findings show that regardless of Rio de Janeiro and Porto Alegre having the two lowest averages, which would mean less attractiveness in Marston's (1985) sense, these two cities have got some important aspects. Rio is able to keep its unemployment rates low whereas the other metropolitan areas do not manage to do the same. Porto Alegre has the second lowest mean

but does not manage to get rid of the hysteresis effect. Thus, we can infer that the other metropolitan regions converge to a higher level of unemployment once unemployment rates in Porto Alegre are relatively low. It means that the other cities will have problems in bringing their unemployment rates down, which could be seen as an extra cost of the tight conduct of monetary policy towards the end of the 1990s, as noted by Mikhail et al (2005) when studying the Canadian case.

There is no doubt the results are extremely important in terms of economic policy as they can be used by policymakers to make crucial decision related to mitigating unemployment and improve social standards of the Brazilian population.

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Appendix

Table A1 reports the critical values for LM unit root test with one/two breaks.

[Insert Table A1]

Figures

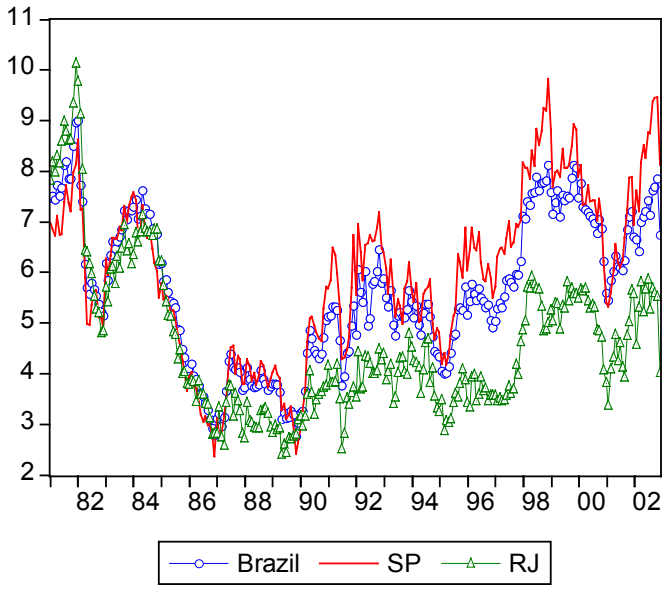

Figure 1. *The Evolution of Regional Unemployment. Data source: IBGE*

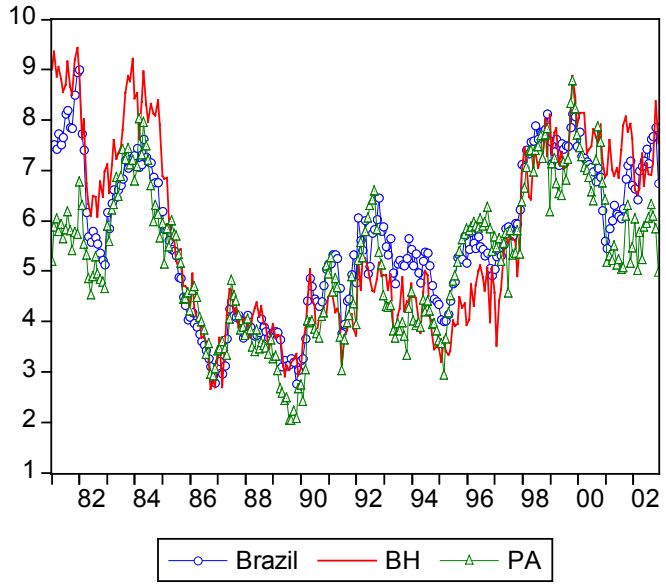

Figure 2. *The Evolution of Regional Unemployment. Data source: IBGE*

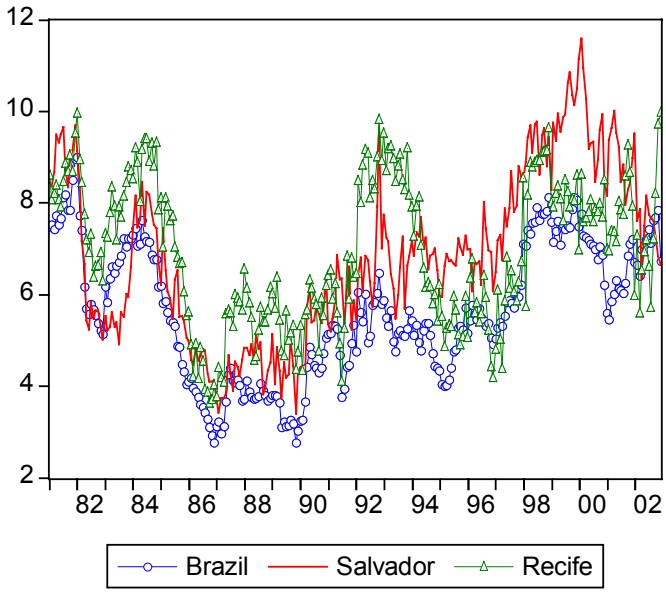

Figure 3. *The Evolution of Regional Unemployment. Data source: IBGE*

Figure 4. *Unemployment and Trend Function*

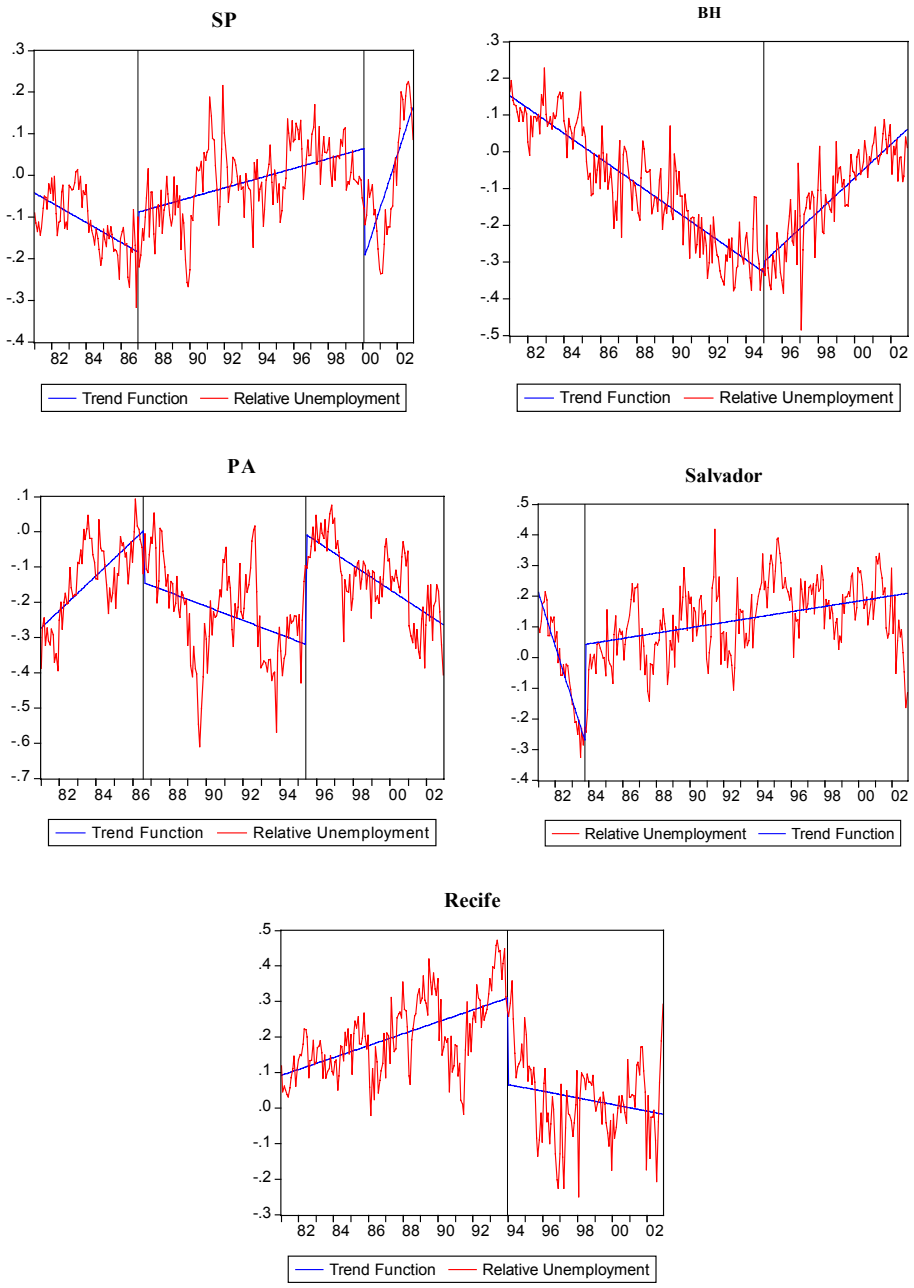

Figure 5. *Relative Unemployment and Trend Function*

Tables

Table 1. *Descriptive Statistics: monthly unemployment rates*

Statistics	Brazil	São Paulo	Rio de Janeiro	Belo Horizonte	Porto Alegre	Salvador	Recife
Mean	5.631	5.942	4.597	5.670	5.187	6.844	6.932
Median	5.498	6.028	4.113	5.047	5.239	6.730	6.914
Maximum	9.003	9.833	10.138	9.429	8.773	11.588	9.986
Minimum	2.763	2.370	2.400	2.656	2.027	3.413	3.633
Std. Dev.	1.461	1.644	1.508	1.844	1.418	1.841	1.570
Observations	264	264	264	264	264	264	264

Table 2. *Correlation: monthly unemployment rates*

	Brazil	São Paulo	Rio de Janeiro	Belo Horizonte	Porto Alegre	Salvador	Recife
Brazil	1.000						
São Paulo	0.943	1.000					
Rio de Janeiro	0.835	0.640	1.000				
Belo Horizonte	0.912	0.770	0.866	1.000			
Porto Alegre	0.869	0.844	0.640	0.798	1.000		
Salvador	0.826	0.802	0.554	0.698	0.724	1.000	
Recife	0.786	0.709	0.672	0.720	0.635	0.611	1.000

Table 3. *Regional Unemployment ADF Test*

Region	Specification			Test Statistic	Critical Values		Reject H_0 (Unit Root)	
	K	**Constant**	**Trend**		**5%**	**10%**	**5%**	**10%**
Brazil	6	Yes	Yes	-2.799	-3.428	-3.137	No	No
São Paulo	6	Yes	Yes	-2.838	-3.428	-3.137	No	No
Rio de Janeiro	8	Yes	No	-3.453	-2.873	-2.573	Yes	Yes
Belo Horizonte	1	Yes	No	-2.102	-2.873	-2.573	No	No
Porto Alegre	1	Yes	No	-2.299	-2.873	-2.573	No	No
Salvador	2	Yes	Yes	-3.025	-3.428	-3.137	No	No
Recife	7	Yes	No	-2.729	-2.873	-2.573	No	Yes

Note: The constant and the linear term where included when they were significant at 10%. The critical values for the ADF unit root test are from MacKinnon (1996).

Table 4. *Regional Unemployment Two-Break LM Test*

Region	*k*	Test statistic	Break dates		Reject H_0:Unit Root	
			T_{B1} (λ_1)	T_{B2} (λ_2)	5%	10%
Brazil	8	-4.936	1985:07 (0.2)	1998:03 (0.8)	No	No
São Paulo	6	-4.529	1985:07 (0.2)	1998:01 (0.8)	No	No
Rio de Janeiro	8	-6.333	1986:05 (0.2)	1997:10 (0.8)	Yes	Yes
Belo Horizonte	0	-5.178	1985:03 (0.2)	1998:02 (0.8)	No	No
Porto Alegre	7	-4.541	1986:03 (0.2)	1998:05 (0.8)	No	No
Salvador	1	-3.966	1989:10 (0.4)	-	No	No
Recife	7	-4.479	1991:06 (0.5)	1994:12 (0.6)	No	No

Note: Critical values from Lee & Strazicich (1999) and Lee & Strazicich (2003), as a function of the location of the break(s), are reported in appendix.

Table 5. *Population, age and formal education*

City	Population Growth (% year)	People over 65 years of age (% in 1991)	People over 65 years of age (% in 2000)	People between 18 and 24 years of age with 12+ years of formal education (% in 1991)	People between 18 and 24 years of age with 12+ years of formal education (% in 2000)
Belo Horizonte	0.86	4.69	6.22	9.52	12.70
Porto Alegre	0.70	6.62	8.36	17.61	21.80
Recife	0.69	5.28	6.51	8.76	11.10
Rio de Janeiro	0.56	7.36	9.12	13.41	14.67
Salvador	1.36	3.57	4.56	6.19	7.82
São Paulo	0.65	5.18	6.43	10.71	13.97

Source: Brazilian Human Development Report.

Table 6. *Regional Unemployment Stochastic Convergence: ADF test*

Region	Specification			Test Statistic	Critical Values		Reject H_0:Unit Root	
	K	Constant	Trend		5%	10%	5%	10%
São Paulo	1	Yes	Yes	-4,523	-3,428	-3,137	Yes	Yes
Belo Horizonte	8	No	No	-1,036	-1,942	-1,616	No	No
Porto Alegre	6	Yes	No	-3,107	-2,873	-2,573	Yes	Yes
Salvador	4	Yes	Yes	-3,323	-3,428	-3,137	No	Yes
Recife	4	Yes	No	-2,377	-2,873	-2,573	No	No

Note: The constant and the linear term where included when they were significant at 10%. The critical values for the ADF unit root test are from MacKinnon (1996).

Table 7. *Regional Unemployment Stochastic Convergence: two-break LM test*

Region	*k*	Test statistic	Break dates		Reject H_0:Unit Root	
			T_{B1} (λ_1)	T_{B2} (λ_2)	5%	10%
São Paulo	0	-6.692	1987:01 (0.3)	2000:02 (0.9)	Yes	Yes
Belo Horizonte	0	-11.444	1995:01 (0.6)	-	Yes	Yes
Porto Alegre	1	-5.197	1986:08 (0.3)	1995:06 (0.7)	No	No
Salvador	1	-5.448	1983:10 (0.1)	-	Yes	Yes
Recife	1	-5.457	1994:01 (0.6)	-	Yes	Yes

Note: Critical values from Lee & Strazicich (1999) and Lee & Strazicich (2003), as a function of the location of the break(s), are reported in appendix.

Table 8. *Migration - People 5+ years of age*

PERIOD: 1986/1991						
PLACES OF ORIGIN	**PLACES OF DESTINY**					
	Total	North	Northwest	Southeast	South	Center-West
Total	3,292,146	412,409	482,794	1,461,037	299,458	636,448
North	277,298		79,463	73,275	29,182	95,379
Northwest	1,354,441	216,979		917,482	21,562	198,418
Southeast	786,815	78,945	334,434		170,418	203,019
South	470,641	41,421	16,630	282,118		130,471
Center-West	336,734	71,177	47,381	154,068	64,108	
Foreign Countries	66,217	3,886	4,887	34,095	14,188	9,161
PERIOD: 1995/2000						
PLACES OF ORIGIN	**PLACES OF DESTINY**					
	Total	North	Northwest	Southeast	South	Center-West
Total	3,506,679	362,840	655,797	1,466,641	378,508	642,892
North	292,751		86,836	68,186	22,956	114,773
Northwest	1,411,421	182,709		969,435	31,029	228,247
Southeast	946,286	75,467	462,628		214,918	193,274
South	349,813	26,989	27,897	205,975		88,952
Center-West	363,275	70,271	70,012	161,276	61,716	
Foreign Countries	143,133	7,404	8,425	61,768	47,890	17,647

Source: IBGE - National Bureau of Geography and Statistics (Census 2000)

Table A1. *LM unit root test with one/two breaks critical values*

One-Break Test			**Two-Break Test**		
Break points	Critical Values		Break points	Critical Values	
	5%	10%		5%	10%
$\lambda = (0.1)$	-4.50	-4.21	$\lambda = (0.2,0.4)$	-5.59	-5.27
$\lambda = (0.2)$	-4.47	-4.20	$\lambda = (0.2,0.6)$	-5.74	-5.32
$\lambda = (0.3)$	-4.45	-4.18	$\lambda = (0.2,0.8)$	-5.71	-5.33
$\lambda = (0.4)$	-4.50	-4.18	$\lambda = (0.4,0.6)$	-5.67	-5.31
$\lambda = (0.5)$	-4.51	-4.17	$\lambda = (0.4,0.8)$	-5.65	-5.32
-	-	-	$\lambda = (0.6,0.8)$	-5.73	-5.32

Note: Critical values from Lee & Strazicich (1999, 2003) for one-break and two-break LM unit root test (Model C), respectively. The critical values depend on the location of the break(s), λ, and are symmetric around λ and $1-\lambda$. Critical values at additional break points can be interpolated.