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Astrid Ayala
Juncal Cuñado
Luis Albériko Gil-Alana

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UNEMPLOYMENT HYSTERESIS: EMPIRICAL EVIDENCE FOR LATIN AMERICA

ASTRID AYALA*

Universidad Francisco Marroquín

JUNCAL CUÑADO AND LUIS ALBÉRIKO GIL-ALANA

Universidad de Navarra

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This paper analyzes the unemployment dynamics of 18 Latin American countries for the last four decades. We use a time series approach to test the mean reversion of unemployment rates and its approximation to a Natural Rate of Unemployment (NRU). The tests include the possibility of one and two structural changes to account for the occurrence of significant macroeconomic changes experienced by the Latin American economies. In addition, we estimate the order of integration of the series, allowing for fractional degrees of differentiation, to assess the persistence of unemployment in the region. Our results indicate that when endogenous structural changes are included in the model, in general we find evidence of mean reversion of unemployment rates for the Latin American countries under study. Therefore, our findings support the structuralist hypothesis of unemployment.

JEL classification codes: C32, E24, O54

Key words: Latin America, unemployment, hysteresis hypothesis, unit root tests, endogenous structural changes, fractional integration

I. Introduction

In recent years there has been an emerging body of empirical literature on the dynamic properties of unemployment rates. Four theories have been developed to explain the

* Astrid Ayala (corresponding author): Universidad Francisco Marroquín, School of Business, Edificio de la Escuela de Negocios, 6 Calle final, zona 10, 01010, Guatemala, Guatemala; phone: (+502) 2338-7941, 2338-7783; fax: (+502) 2338-7963; email: aayala@ufm.edu. Juncal Cuñado: School of Economics and Business Administration, Universidad de Navarra, Edificio Bibliotecas-Este, 31080 Pamplona, Spain; email: jcuñado@unav.es. Luis A. Gil-Alana: School of Economics and Business Administration, Universidad de Navarra, Edificio Bibliotecas-Este, 31080 Pamplona, Spain; email: alana@unav.es. Comments from the Editor and an anonymous referee are gratefully acknowledged.

behavior of unemployment. (1) The *Natural Rate of Unemployment* (NRU) hypothesis implies the existence of a unique long run equilibrium for unemployment rates (Phelps 1967, 1972; Friedman 1968). Nevertheless, in the short run there may be temporary deviations from the long run equilibrium. Therefore, this hypothesis suggests that the unemployment rate is a stationary and mean reverting process where shocks only have transitory effects. (2) The *structuralist* hypothesis establishes that changes in fundamentals may shift the level of the equilibrium unemployment rate over time (Phelps 1994). According to this theory, the unemployment rate is a stationary process subject to occasional but persistent structural changes. As in the traditional theory, in structuralist models, fluctuations in unemployment are considered as movements around the NRU. (3) The *persistence* hypothesis implies a slow speed of adjustment toward the long run equilibrium unemployment rate after a shock. Therefore, the unemployment rates may exhibit characteristics of nonstationary long memory processes. (4) The *hysteresis* hypothesis states that the unemployment rates can be characterized as nonstationary unit root processes that never revert to equilibrium after a shock (Blanchard and Summers 1986, 1987; Cross 1987; Barro 1988). Therefore, the temporary shocks have permanent effects on the unemployment rate. Some explanations provided for this explosive behavior include the existence of strong unions, worker protection laws, human capital depreciation during unemployment, excessively high real wages and the social stigma of the long term unemployed (Phelps 1972; Blanchard and Summers 1986, 1987; Clark 2003; Layard et al. 2005).

In this article, we test these unemployment theories for the Latin American region motivated, at least, by the following reasons. First, the high and persistent unemployment rates in the region cast serious doubts on the NRU theory. Second, the study of the dynamics of unemployment rates in Latin America may enable the policy makers to identify if efforts should be made to prevent short run deviations from equilibrium or to develop structural reforms, such as labor market reforms and social protection networks. Third, Latin America is a region that has undergone several booms and busts, that may be interpreted as frequent significant shocks (structural changes). Fourth, the high unemployment rates in Latin America have important effects on the migratory flows of the labor force to the United States and Europe. Fifth, there is insufficient research into the unemployment dynamics in Latin America, due to restrictions in the availability of the data.

There are several empirical works, which test the different unemployment theories. Initially, the order of integration of unemployment was analyzed by using standard unit root tests, such as the Augmented Dickey-Fuller (ADF, Dickey and Fuller 1979) or the Phillips-Perron (1988) tests. The findings in this context are

mixed.¹ It is important to consider at this stage that the standard unit root tests may lead to erroneous conclusions when structural breaks are present in the series (Perron 1989). As a consequence, several studies implemented unit root methods with structural breaks in order to test the structuralist hypothesis.² The main advantage of this framework is that it can model, for instance, less stable economies of emerging or developing countries. In general, these studies present evidence that favors the structuralist hypothesis over the hysteresis theory. The unit root tests described previously do not test the persistence hypothesis, which states that unemployment shocks may fade away after a long period of time. In other words, the unit root tests may fail to reject the null hypothesis of fractional integration with a differencing parameter near to but less than one. In this case, although the variable is not stationary, it still presents mean reversion. To counter this problem, some papers employ fractional integration.³ The advantage of this approach lies in its flexibility as these models may capture complex unemployment dynamics.

As it has been mentioned previously, there are few papers analyzing the unemployment rates for the Latin American region. Most of these works study regional level unemployment within some Latin American countries. Arrufat et al. (1999) test the hysteresis hypothesis for regional unemployment in Argentina during the period 1980 to 1998. They reject the unit root null hypothesis when structural breaks are considered, i.e., the structural hypothesis is evidenced. Figueiredo (2010) investigates the unemployment dynamics in Brazil and in its major metropolitan regions by using a fractional integration model with regime switching dynamics. The author identifies two different regimes. The first one is non-mean-reverting (hysteresis hypothesis), whereas the second one is nonstationary but mean-reverting (persistence hypothesis). Gomes and Silva (2009) find evidence in support of the hysteresis hypothesis in six Brazilian metropolitan areas for the period 1981-2002, by using unit root tests with structural breaks on monthly unemployment rate data. To the best of our knowledge, the only country level paper on the unemployment rate dynamics in Latin America is Mednik et al. (2011), who test the hysteresis hypothesis in 13 countries for the period 1980-2005. Their findings provide support for the hysteresis hypothesis in the majority of the countries under study. Nevertheless,

¹ See Alogoskoufis and Manning (1988), Gordon (1989) and Graafland (1991).

² See, for example, Bianchi and Zoega (1998), Papell et al. (2000), and Chien-Chiang and Chun-Ping (2008).

³ See Tschernig and Zimmermann (1992), Gil-Alana (2001a, 2001b) and Reisen et al. (2003). Fractionally integrated processes will be defined in Section II.

the authors mention that some of their results are sensitive to higher frequency data or longer time series that were not available for the majority of the countries analyzed. In particular, Mednik et al. (2011) report that their test results about the structuralist hypothesis (panel unit root tests with structural breaks) are not very reliable due to the small sample size (25 years, annual data).

In this study, we analyze the statistical properties of annual data of the unemployment rates of 18 Latin American countries for more than three decades. In particular, we test if the unemployment rates exhibit mean reverting or unit root behavior. We use (1) unit root tests including endogenous structural changes and (2) parametric models based on fractional integration. These test procedures can provide us with an idea of the degree of persistence of the unemployment in the region. Therefore, they can allow us to verify which of the economic theories characterize the unemployment dynamics in Latin America.

The main contributions of this article are the following. First, we use an extended data set, both in terms of the number of Latin American countries studied (18 countries) and the number of years observed (more than three decades; see Table 2), in comparison to previous country level papers in the literature. Second, the econometric methods applied in the article provide tests for the four unemployment theories (NRU, structuralist, persistence and hysteresis hypotheses). This article is an extension of Mednik et al. (2011) since –besides the test of the NRU, structuralist and hysteresis hypotheses tested by these authors– we also perform a fractional integration-based test for the persistence hypothesis.

The remaining part of this article is organized as follows. In Section II, we present the econometric methodology employed. Section III describes the data set. Section IV presents our empirical findings. Finally, Section V offers some conclusions.

II. Methodology

This section contains three parts. In Section A, we introduce some notation and definitions related to the general model and define the concept of mean reversion. In Section B, we present some alternative tests of mean reversion in the unit root test framework. In Section C, the methodology of fractional integration is presented.

A. Basic notation and definitions

We are in a univariate time series framework, i.e., we observe random variables, over $t = 1, \dots, T$ periods. Let y_t denote the unemployment rate for period t . We are

interested in the stochastic properties of the time series $\{y_t : t = 1, \dots, T\}$.⁴ The focus of this study is to verify the properties of y_t computed for several Latin American countries. We need to specify an econometric model for y_t in order to understand its properties. Let us write this model in a general form as follows:

$$y_t = \delta' Z_t + x_t, \quad (1)$$

where $t = 1, \dots, T$, Z_t is an $m \times 1$ vector of explanatory variables, δ is an $m \times 1$ vector of parameters and x_t is the error term driving the y_t process. We shall specify the exact form of $\delta' Z_t$ in Sections B and C. The main component determining the stochastic properties of y_t is the error term, x_t , which may be specified as follows: (a) an integrated of order zero process, $I(0)$; (b) a unit root process or an integrated of order one process, $I(1)$; (c) a fractionally integrated process, $I(d)$, where d is a fractional value. In the followings, we present the relevant definitions for our empirical work.

Definition 1 (integration of order zero): A process x_t is said to be integrated of order zero, and denoted by $x_t \approx I(0)$, if it is a covariance stationary process, with autocovariance function $\gamma_u = E\{[x_t - E(x_t)][x_{t+u} - E(x_t)]\}$ satisfying the following property:

$$\sum_{u=-\infty}^{\infty} |\gamma_u| < \infty. \quad (2)$$

Alternatively, assuming that x_t has an absolutely continuous spectral distribution function, so that it has a spectral density function, $f(\lambda)$, y_t is said to be $I(0)$ if the spectral density function is positive and bounded at all frequencies in the spectrum, i.e., $0 < f(\lambda) < \infty$, for all λ . The $I(0)$ class includes the white noise case, but also weakly autocorrelated (e.g., ARMA) processes.

Definition 2 (unit root process): A process x_t is said to contain a unit root or is said to be integrated of order one, $x_t \approx I(1)$, if

$$x_t = x_{t-1} + u_t, \quad (3)$$

⁴ The NRU hypothesis implies that $\lim_{k \rightarrow \infty} E[y_{t+k} | F_t] = \mu$, where F_t means the information available up to time t . Moreover, full employment can be expressed as $\lim_{k \rightarrow \infty} E[y_{t+k} | F_t] = 0$.

where the u_t error term is supposed to be an $I(0)$ process. Note that this specification includes the random walk model but also ARIMA-type processes.

Definition 3 (fractionally integrated process): A process x_t is said to be fractionally integrated or $I(d)$ with order of integration $d > 0$ if

$$(1-L)^d x_t = u_t, \quad (4)$$

where L is the lag operator, i.e., $Lx_t = x_{t-1}$, and u_t is an $I(0)$ error term.⁵

Several stochastic properties of x_t defined in (4) are determined by d . If $0 \leq d < 0.5$, then x_t is covariance stationary and shocks disappear in the long run relatively fast. If $0.5 \leq d < 1$, then x_t is not covariance stationary, and shocks, though mean reverting, take a longer time to disappear than in the previous case. If $d = 1$, then x_t contains a unit root and shocks do not die away over the long run. If $d > 1$, the series is not covariance stationary and its impact is permanent.

Definition 4 (mean reverting process): If $0 \leq d < 1$, then x_t is a mean reverting process.

Reviewing the above properties, we can say that the higher d is, the “longer” the “memory” of the process is. Therefore, the order of integration of x_t can be interpreted as a characteristic of the unemployment rates of the countries. The lower d is, the higher the speed of mean reversion is. Estimating d helps us then to conclude about the memory of the process, i.e., do shocks die away in a relatively short or long run. Table 1 shows the implications of the different values of d , which correspond to the alternative unemployment hypotheses presented previously.

Table 1. Order of integration of unemployment rate and hypothesis fulfilled

Order of integration	Hypothesis
$d \in (0, 0.5)$	NRU
$d \in (0, 0.5) + \text{structural changes}$	Structuralist
$d \in [0.5, 1)$	Persistence
$d \geq 1$	Hysteresis

Notes: Natural Rate of Unemployment (NRU).

⁵ Note that an $I(0)$ process is also named short memory as opposed to the case of long memory if $d > 0$. Long memory is so named because of the strong association between observations widely separated in time.

In our methodology, we employ several test procedures to evaluate mean reversion of unemployment rates of several Latin American countries. First, Section B presents existing tests for $H_0: d = 1$, i.e., testing if x_t contains a unit root. Then, Section C presents existing tests for $H_0: d = d_0$ where $0 \leq d_0 \leq 2$ for a grid of values of d_0 in order to approximate the order of integration of x_t from a fractional viewpoint.

B. Existence of mean reversion – unit root tests

In this section, we present various unit root tests. These tests will be applied in the empirical section to verify the existence of mean reversion in the unemployment rates.

The null hypothesis, H_0 , in each test is that x_t forms a unit root process, i.e., that the process is not mean reverting. The alternative hypothesis, H_1 , is in all cases that the process does not contain a unit root but is stationary $I(0)$, i.e., it is mean reverting. In other words, when H_0 cannot be rejected then unemployment rates form a unit root process. On the other hand, when H_0 is rejected then there is evidence of mean reversion in the unemployment rates. Alternative formulations of the $\delta'Z_t$ term lead to alternative unit root tests.

The first test employed is the traditional ADF unit root test. Moreover, we also consider alternative unit root tests incorporating structural changes (Lee and Strazicich, henceforth LS, 2003, 2004). The rationale for using unit root tests that include structural breaks is based on the facts presented in Section III in which data analysis suggest that structural breaks took place in some countries in Latin America. In the remaining part of this subsection, some details of each unit root test are summarized.

Unit root test without structural breaks

The first test applied to verify the mean reversion in the unemployment rates is the ADF test. The estimated specification includes a constant and a time trend. However, it does not consider structural changes in the time series.

If we reject the unit root null hypothesis with the ADF test, we run the following regression to test whether y_t approximates NRU or full employment rate:

$$y_t = \mu + \beta t + u_t, \quad (5)$$

where u_t is a possibly serially correlated error term. Regarding the approximation to NRU, we can have different conclusions depending on the estimated parameter values:

F (*full employment*): μ and β are both insignificant at a given significance level, say 10 percent ($\mu = 0, \beta = 0$).

N (NRU): μ is significantly different from zero, and β is statistically insignificant ($\mu \neq 0, \beta = 0$).

C (*decreasing unemployment*): μ is significantly positive and β is significantly negative ($\mu > 0, \beta < 0$).

D (*divergence from different levels*): μ and β have the same sign and they are both significantly different from zero ($\mu \neq 0, \beta \neq 0$).

d (*divergence from full employment*): μ is insignificantly different from zero and β is statistically significant ($\mu = 0, \beta \neq 0$).

We use this notation in Section IV, where the empirical findings are examined.

Unit root test with one structural break

There are several unit root tests that consider the possibility of a structural break in y_t (Perron 1989; Zivot and Andrews 1992; Perron 1997; Vogelsang and Perron 1998). A common feature of the previous tests is that they omit the possibility of a unit root with break. Therefore, spurious rejections of H_0 may occur. LS (2004) extend these unit root tests since they consider a unit root with break under the null hypothesis. In the LS (2004) test, the following regression is estimated:

$$\Delta y_t = \delta' \Delta Z_t + \phi \tilde{S}_{t-1} + \sum_{j=1}^k c_j \Delta \tilde{S}_{t-j} + e_t, \quad (6)$$

where Δ denotes the first differences of the corresponding time series, $\tilde{S}_t = y_t - \tilde{\Psi}_x - Z_t \tilde{\delta}$ and $\tilde{\Psi}_x = y_1 - Z_1 \tilde{\delta}$. The $\tilde{\delta}$ parameters denote coefficients estimated by a regression of Δy_t on ΔZ_t , $Z_t = [1, t, D_t, DT_t]'$ and $\Delta Z_t = [1, \Delta D_t, \Delta DT_t]'$. The $\Delta \tilde{S}_{t-j}$ terms are included to correct for serial correlation.⁶

In the case of rejecting the unit root hypothesis of the LS (2004) test, we test whether NRU is approximated before and after the estimated date of structural change by using the following regression model:

$$y_t = \mu_1 DU_{1t} + \mu_2 DU_{2t} + \beta_1 TIME_{1t} + \beta_2 TIME_{2t} + u_t, \quad (7)$$

⁶ The specification of $\delta' Z_t$ in equation (1) in this test is $\delta_0 + \delta_1 t + \delta_2 D_t + \delta_3 DT_t$. See LS (2004) for the selection of the number of augmentation terms, k .

where $DU_{1t} = 1$ if $t \leq T_B$ and zero otherwise, $DU_{2t} = 1$ if $t > T_B$ and zero otherwise, $TIME_{1t} = t$ if $t \leq T_B$ and zero otherwise, and $TIME_{2t} = t - T_B$ if $t > T_B$ and zero otherwise. The $\hat{\mu}_i$ and $\hat{\beta}_i$ estimates lead us to the same conclusions for each period i as the ones stated after equation (5).

Unit root test with two structural breaks

The unit root tests with a single structural break mentioned in the previous section do not consider that several structural breaks may occur in the economy. This fact motivated Lumsdaine and Papell (1997) to include two structural breaks in their unit root test. However, these authors do not consider structural breaks under the null hypothesis. LS (2003) address this problem by including two structural breaks in the null hypothesis. Compared to the LS (2004) model, the only difference in the LS (2003) model notation in equation (6) is that $Z_t = [1, t, D_{1t}, D_{2t}, DT_{1t}, DT_{2t}]'$ and that $\Delta Z_t = [1, \Delta D_{1t}, \Delta D_{2t}, \Delta DT_{1t}, \Delta DT_{2t}]'$.⁷

When we reject the unit root hypothesis of the LS (2003) test, we test if unemployment rate approximates NRU before and after the estimated date of structural changes by estimating the following regression model:

$$y_t = \mu_1 DU_{1t} + \mu_2 DU_{2t} + \mu_3 DU_{3t} + \beta_1 TIME_{1t} + \beta_2 TIME_{2t} + \beta_3 TIME_{3t} + u_t, \quad (8)$$

where $DU_{1t} = 1$ if $t \leq T_{1B}$ and zero otherwise, $DU_{2t} = 1$ if $T_{1B} < t \leq T_{2B}$ and zero otherwise, $DU_{3t} = 1$ if $t > T_{2B}$ and zero otherwise, $TIME_{1t} = t$ if $t \leq T_{1B}$ and zero otherwise, $TIME_{2t} = t - T_{1B}$ if $T_{1B} < t \leq T_{2B}$ and zero otherwise, and $TIME_{3t} = t - T_{2B}$ if $t > T_{2B}$ and zero otherwise. The $\hat{\mu}_i$ and $\hat{\beta}_i$ estimates lead us to the same conclusions for each period i as the ones stated after equation (5).

C. Properties of unemployment rate – fractional integration

In Section A, we defined the concept of $I(d)$ processes and briefly presented the main properties of x_t depending on d . We can say that the higher d is, the “longer” the “memory” of the integrated process is. The lower d is, the higher the speed of mean reversion. The estimation of d helps to reach a conclusion concerning the memory of the process.

⁷ The specification of $\delta'Z_t$ in equation (1) in this test is $\delta_0 + \delta_1 t + \delta_2 D_{1t} + \delta_3 D_{2t} + \delta_4 DT_{1t} + \delta_5 DT_{2t}$.

There exist many approaches for estimating and testing the fractional differencing parameter d .⁸ We employ in this work a parametric approach to estimate the degree of integration of the series. We use the LM test of Robinson (1994) testing $H_0: d = d_0$ for any real value d_0 , in the model given by the equation (1), where x_t is defined by (4). Robinson (1994) derived the asymptotic distribution of the test statistic and also showed the Pitman efficiency of the test against local departures from the null. In this context, we are in a classical large-sample testing situation: an approximate one-sided 100α percent level test of H_0 against the alternative: $H_1: d > d_0$ ($d < d_0$) will be given by the rule: "Reject H_0 if $\hat{r} > z_\alpha$ ($\hat{r} < -z_\alpha$)," where the probability that a standard normal random variable exceeds z_α is α .⁹

III. Data

The data used in this study are the annual unemployment rates for 18 Latin American countries. The countries under study are the following: Argentina, Barbados, Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, Guatemala, Jamaica, Mexico, Panama, Paraguay, Peru, Trinidad & Tobago, Uruguay and Venezuela. The starting year for each country is presented in Table 2. The source of the data is described in the Data Sources section.

Table 2 presents the descriptive statistics of the annual unemployment rates in the 18 countries under study. The countries with the highest mean unemployment rate are Jamaica (0.17), Trinidad & Tobago (0.14) and Barbados (0.14), and the economies with the lowest mean unemployment rate are Mexico (0.04), Costa Rica (0.06) and Guatemala (0.06).¹⁰ Reviewing the values of skewness and kurtosis, we can see that the distribution of the annual unemployment rates is not symmetric and not Gaussian.

Figure 1 presents the evolution of unemployment rates for each country under study, for the period 1980 to 2009, to provide graphical representation of the data.

⁸ See Gil-Alana and Hualde (2009) for a recent review of fractional integration in macroeconomic time series.

⁹ An obvious advantage of this approach is that since d_0 can be any real value, it includes stationary ($d_0 < 0.5$) but also nonstationary ($d_0 \geq 0.5$) hypotheses, with no need of preliminary differencing prior to the application of the procedure.

¹⁰ It is worth noting that inter-country comparisons are hampered by the variety of types of sources (labor force sample surveys, official estimates, social insurance statistics and employment office statistics) used to obtain information on unemployment and the differences in the scope and coverage of such sources.

Figure 1. Unemployment rate from 1980 to 2009 for 18 Latin American countries

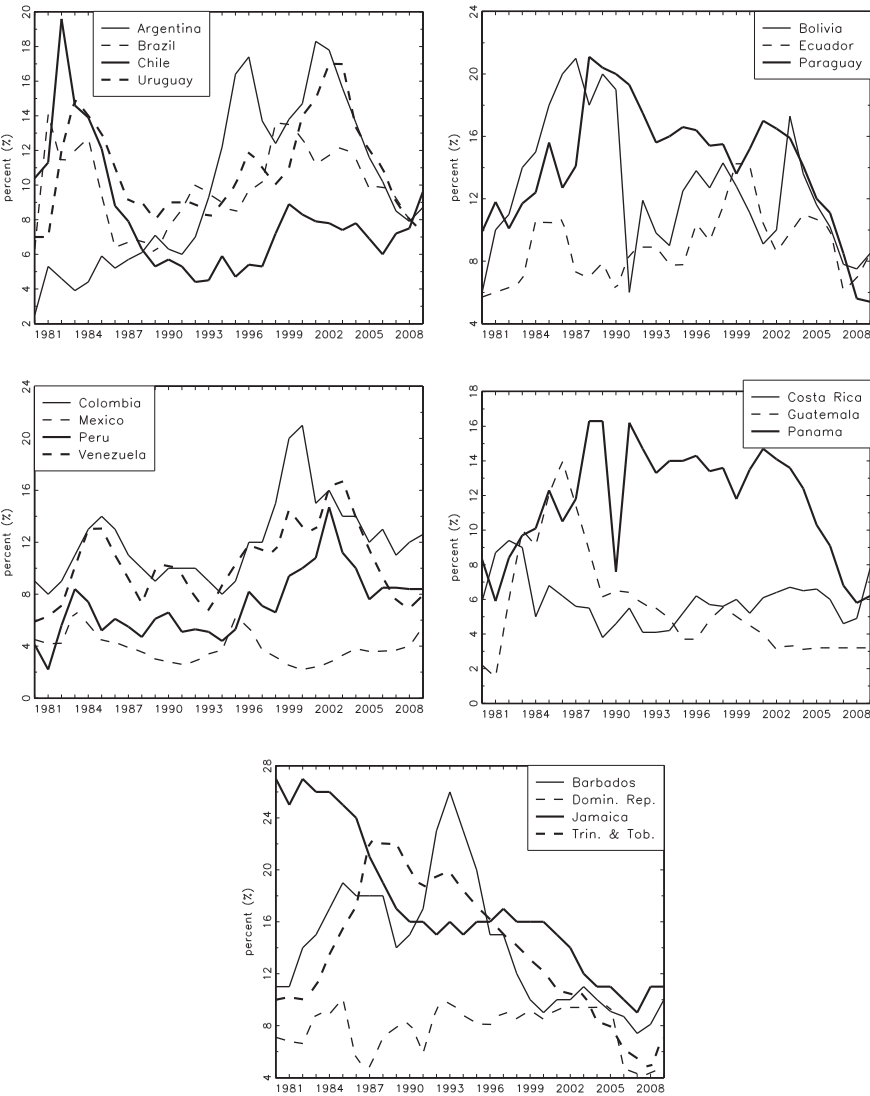


Table 2. Descriptive statistics of unemployment rate

Country	Mean	Med	Max	Min	SD	Skew	Kurt	Start	T
Argentina	0.08	0.06	0.18	0.02	0.05	0.68	2.21	1970	40
Barbados	0.14	0.14	0.26	0.07	0.05	0.64	2.55	1980	30
Bolivia	0.13	0.12	0.21	0.06	0.04	0.39	2.20	1980	30
Brazil	0.09	0.09	0.14	0.02	0.03	-0.62	2.77	1976	34
Chile	0.09	0.08	0.20	0.04	0.04	0.95	3.28	1975	35
Colombia	0.12	0.12	0.21	0.08	0.03	1.12	4.19	1980	30
Costa Rica	0.06	0.06	0.09	0.04	0.01	0.94	3.64	1976	34
Domin. Rep.	0.08	0.08	0.10	0.04	0.02	-0.69	2.10	1980	30
Ecuador	0.09	0.09	0.14	0.06	0.02	0.59	2.95	1980	30
Guatemala	0.06	0.05	0.14	0.02	0.03	1.20	3.66	1980	30
Jamaica	0.17	0.16	0.27	0.09	0.05	0.53	2.16	1980	30
Mexico	0.04	0.04	0.08	0.02	0.02	0.65	2.22	1973	37
Panama	0.11	0.10	0.16	0.06	0.03	0.14	1.62	1970	40
Paraguay	0.14	0.15	0.21	0.05	0.04	-0.44	2.91	1980	30
Peru	0.07	0.07	0.15	0.02	0.03	0.71	3.78	1980	30
Trin. & Tob.	0.14	0.13	0.22	0.05	0.05	0.16	2.05	1977	33
Uruguay	0.11	0.11	0.17	0.07	0.03	0.60	2.43	1980	30
Venezuela	0.10	0.10	0.17	0.05	0.03	0.37	2.31	1975	35

Notes: Med, SD, Skew, Kurt and Start denote median, standard deviation, skewness, kurtosis and starting year of observations, respectively. The final year of observations for all countries is 2009. T denotes the sample size for each country.

IV. Empirical results

First, we present the results obtained for the unit root tests and conclude about the mean reversion of the unemployment rates in Section A. Then, we analyze the approximation to the NRU for the countries under study in Section B. Finally, we present the fractional integration results in Section C.

A. Unit root tests results

Table 3 shows the unit root test results for the ADF (1979), LS (2004) and LS (2003) statistics.¹¹ The critical values used for the LS (2004) and LS (2003) tests can be found in the corresponding papers.

For the ADF test, we obtain evidence of mean reversion only for Guatemala, while the unit root hypothesis cannot be rejected for the rest of the countries, i.e., for most Latin American countries the hysteresis hypothesis is evidenced. Note, however, that the classical ADF test involves a relatively simple time series model, which excludes the occurrence of significant macroeconomic changes.

For the LS (2004) unit root test, which includes one structural break, we find evidence of mean reversion in 9 of the 18 economies: Barbados, Chile, Dominican Republic, Guatemala, Jamaica, Panama, Paraguay, Peru and Venezuela, i.e., the structuralist hypothesis is supported for these countries. As the model employed in LS (2004) is more complex, it captures mean reversion for more countries than the ADF test. However, for several countries the unit root test, which includes only one break point, is not flexible enough to characterize the evolution of the unemployment rates.

Finally, for the LS (2003) procedure that includes two structural breaks, we find evidence of mean reversion of unemployment rates, i.e., the structuralist hypothesis is evidenced, in 16 of the 18 Latin American countries. In particular, we cannot reject the unit root null hypothesis for Bolivia and Ecuador.

From the unit root test results reported above, we notice that the countries that do not exhibit mean reversion of unemployment rates under any specification are Bolivia and Ecuador. This may possibly be caused by the presence of more than two structural breaks in the unemployment rate series of these countries during the period analyzed.

¹¹ The unit root tests of LS (2003) and LS (2004) were performed using the Gauss codes downloaded from the website of Junsoo Lee (<http://www.cba.ua.edu/~jlee>).

Table 3. Unit root tests of unemployment rate

Country	ADF			LS (2004)			LS (2003)			λ_2	λ_1	U/M
	stat.	LM stat	T_B	λ	LM stat	T_B	LM stat	T_{1B}	T_{2B}			
Argentina	-2.58	-3.96	1992	0.56	-5.70**	1993	-5.70**	1993	2003	0.59	0.85	UUM
Barbados	-3.04	-5.11***	1995	0.52	-9.41***	1990	-9.41***	1990	2000	0.34	0.69	UMM
Bolivia	-2.86	-3.21	1991	0.38	-4.22	1995	-4.22	1995	2002	0.52	0.76	UUU
Brazil	-2.70	-3.92	1988	0.36	-8.11***	1988	-8.11***	1988	1997	0.36	0.64	UUM
Chile	-1.64	-8.00***	1990	0.44	-8.30***	1990	-8.30***	1990	2000	0.44	0.74	UMM
Colombia	-2.33	-4.06	1996	0.55	-5.57*	1991	-5.57*	1991	2000	0.38	0.69	UUM
Costa Rica	-2.93	-4.08	1986	0.30	-6.60***	1988	-6.60***	1988	2005	0.36	0.88	UUM
Domin. Rep.	-2.41	-7.10***	2004	0.83	-11.84***	1994	-11.84***	1994	2004	0.48	0.83	UMM
Ecuador	-3.04	-3.72	1996	0.55	-4.10	1995	-4.10	1995	2005	0.52	0.86	UUU
Guatemala	-5.14***	-7.70***	1990	0.34	-11.79***	1998	-11.79***	1998	2002	0.62	0.76	MMM
Jamaica	-1.39	-4.52**	1993	0.45	-7.22***	1990	-7.22***	1990	2001	0.34	0.72	UMM
Mexico	-2.15	-3.67	1985	0.33	-5.40*	1992	-5.40*	1992	1997	0.53	0.67	UUM
Panama	-0.90	-4.59**	1992	0.56	-6.55***	1983	-6.55***	1983	2004	0.33	0.87	UMM
Paraguay	-0.92	-5.89***	1998	0.62	-7.37***	1996	-7.37***	1996	2006	0.55	0.90	UMM
Peru	-2.69	-4.31*	1997	0.59	-5.65**	1992	-5.65**	1992	2002	0.41	0.76	UMM
Trin. & Tob.	-1.75	-3.88	1996	0.59	-5.92**	1990	-5.92**	1990	2002	0.41	0.78	UUM
Uruguay	-2.89	-3.76	1997	0.59	-8.40***	2000	-8.40***	2000	2004	0.69	0.83	UUM
Venezuela	-2.81	-4.48**	1998	0.68	-5.60*	1991	-5.60*	1991	2003	0.47	0.82	UMM

Notes: T_B and T_{1B} denote the year of the structural break for LS (2004) and LS (2003), respectively. The 0.5 and 1 percent critical values of the ADF model are -3.17, -3.49, -4.13, respectively. The critical values for the LS (2004) model, which depend on $\lambda = T_B/T$, are presented in LS (2004). The critical values for the LS (2003) model, which depend on $\lambda_1 = T_{1B}/T$, can be found in LS (2003). *, **, and *** denote test statistic significant at the 10, 5 and 1 percent level, respectively. M and U denote mean reversion and unit root, respectively.

We obtained different results from the ones reported by Mednik et al. (2011). They test the hysteresis hypothesis in 13 Latin American countries for a smaller sample period (1980-2005) by using different unit root tests. They find evidence of hysteresis for the majority of the countries by using traditional unit root tests without structural breaks. In addition, Mednik et al. (2011) apply panel unit root tests with structural breaks, finding evidence for the structuralist hypothesis. Nevertheless, they report that their results should be considered with caution due to the small sample size and conclude that the hysteresis hypothesis may characterize the unemployment dynamics in Latin America.

B. NRU approximation results

In this section, we analyze our findings regarding the approximation to NRU for the 18 Latin American economies under study. We present the results of NRU regressions in Table 4 and the corresponding summary findings in Table 5.

Under the ADF, LS (2004) and LS (2003) unit root tests, we cannot reject the unit root null hypothesis for Bolivia and Ecuador. To develop the NRU analysis for the rest of the countries, we used the results of the unit root test with the highest adjusted R-squared. According to the estimation results, the LS (2003) test exhibits the highest adjusted coefficient of determination.

We find evidence of approximation to an NRU after the last break point for Chile, Costa Rica and Guatemala. The unemployment rate is approaching an equilibrium rate for these countries. We find divergence from different levels after the last structural change for Mexico. That is, the unemployment rate of Mexico exhibits an increasing trend during the last period. For the rest of the countries, we witness a reduction in the unemployment rate after the last break point.

C. Fractional integration results

Table 6 reports the estimates of d in equation (4) based on white noise disturbances.¹² Figures in bold indicate the cases where the unit root (i.e., $d = 1$) cannot be rejected at the 5 percent level and the values in squared brackets report the 95 percent confidence band estimated by using Robinson's (1994) parametric approach.

¹² The assumption of uncorrelated disturbances may appear unrealistic. Nevertheless, it may be of interest when testing $I(d)$ hypotheses. In fact, the autocorrelations decay here hyperbolically slow as opposed to the AR structure where the decay is exponentially fast.

Table 4. Parameter estimates of the NRU regressions for alternative unit root tests

Country	ADF			LS (2004)				LS (2003)			
	μ	β	μ_1	β_1	μ_2	β_2	μ_1	β_1	μ_2	β_2	β_3
Argentina							0.04***	0.00*	0.14***	0.00*	-0.01***
Barbados			0.12***	0.01***	0.14***	0.00***	0.13***	0.00	0.26***	-0.02***	0.00**
Bolivia											
Brazil							0.03	0.01*	0.07***	0.00**	-0.01***
Chile			0.16***	-0.01**	0.05***	0.00***	0.16***	-0.01***	0.04***	0.00**	0.00
Colombia							0.10***	0.00	0.05**	0.02***	0.00***
Costa Rica							0.06***	0.00	0.04***	0.00**	0.01
Domin. Rep.			0.07***	0.00***	0.08***	-0.01*	0.07***	0.00	0.08***	0.00**	-0.01*
Ecuador											
Guatemala	0.09***	0.00	0.05*	0.01	0.06***	0.00***	0.08**	0.00	0.06***	-0.01***	0.00
Jamaica			0.29***	-0.01**	0.18***	0.00**	0.30***	-0.01**	0.16***	0.00	0.00**
Mexico							0.08**	0.00**	0.04**	0.00	0.00**
Panama			0.05***	0.00**	0.16***	0.00**	0.06***	0.00**	0.12***	0.00	-0.01***
Paraguay			0.12***	0.00**	0.19***	-0.01**	0.11***	0.00***	0.17***	0.00*	-0.02***
Peru			0.05***	0.00	0.10***	0.00	0.05***	0.00	0.03***	0.01**	0.00**
Trin. & Tob.							0.08***	0.01***	0.21***	-0.01***	-0.01***
Uruguay							0.10***	0.00	0.17***	-0.01	-0.01***
Venezuela			0.06***	0.00***	0.17***	-0.01***	0.05***	0.00**	0.06***	0.01**	-0.01***

Notes: *, ** and *** indicate test statistic significant at the 10, 5 and 1 percent levels, respectively. The empty cells of the table refer to unit root processes. The table presents the results for the following regression models:
ADF: $y_t = \mu + \beta_1 + u_t$
LS (2004): $y_t = \mu_1 DU_{1t} + \mu_2 DU_{2t} + \beta_1 TIME_{1t} + \beta_2 TIME_{2t} + u_t$
LS (2003): $y_t = \mu_1 DU_{1t} + \mu_2 DU_{2t} + \mu_3 DU_{3t} + \beta_1 TIME_{1t} + \beta_2 TIME_{2t} + \beta_3 TIME_{3t} + u_t$.

Table 5. Evaluation of NRU for different unit root tests

Country	ADF	LS (2004)				LS (2003)			
	t	t_1	T_B	t_2	t_1	T_{1B}	t_2	T_{2B}	t_3
Argentina					D	1993	D	2003	C
Barbados		D	1995	C	N	1990	C	2000	C
Bolivia									
Brazil	D				d	1988	D	1997	C
Chile		C	1990	D	C	1990	D	2000	N
Colombia					N	1991	D	2000	C
Costa Rica	N				N	1988	D	2005	N
Domin. Rep.		D	2004	C	N	1994	D	2004	C
Ecuador	N								
Guatemala	C	N	1990	C	N	1998	C	2002	N
Jamaica	C	C	1993	C	C	1990	N	2001	C
Mexico					C	1992	N	1997	D
Panama		D	1992	C	D	1983	N	2004	C
Paraguay		D	1998	C	D	1996	C	2006	C
Peru		N	1997	N	N	1992	D	2002	C
Trin. & Tob.					D	1990	C	2002	C
Uruguay	U				N	2000	N	2004	C
Venezuela		D	1998	C	D	1991	D	2003	C

Notes: t_i denotes the i -th period separated by the structural break times. T_B denotes the year of the structural break. T_{iB} denotes the year of structural break i . F = full employment, N = NRU, C = decreasing unemployment, D = divergence from different levels, d = divergence from full employment. The empty cells of the table refer to unit root processes.

We observe that the unit root hypothesis (i.e., $d = 1$) cannot be rejected in the three models examined (no regressors, an intercept, and an intercept with a linear time trend; see Table 6) for all countries except Trinidad & Tobago, Dominican Republic and Panama. In the cases of an intercept and an intercept with a linear time trend, the $I(1)$ hypothesis is rejected in favor of an order of integration above one for Trinidad & Tobago. Thus, the dynamics of unemployment of 16 of the 18 Latin American countries under study, present evidence in favor of the hysteresis hypothesis. Evidence of mean reversion (i.e., $d < 1$) in unemployment rates is obtained for Dominican Republic and Panama when we include in the model an intercept and an intercept with a linear time trend. For both countries $d \in [0.5, 1)$ in the cases of an intercept and an intercept with a linear time trend. Therefore, for the Dominican Republic and Panama, evidence for the persistence hypothesis is presented.

Our fractional integration results do not provide evidence in favor of the NRU hypothesis for any of the 18 Latin American countries under study. One reason for these findings might be that the stochastic behavior of the unemployment rates of the Latin American countries may be more complicated, and structural breaks may play an important role in describing its behavior. Therefore, there may be a possible bias in the fractional integration results derived from the potential presence of structural breaks in the times series (Diebold and Inoue 2001; Granger and Hyung 2004).

Table 6. Estimates of the order of integration based on white-noise disturbances

Country	Model 1	Model 2	Model 3
Argentina	[0.86 (1.24) 1.84]	[0.97 (1.26) 1.85]	[0.96 (1.26) 1.84]
Barbados	[0.96 (1.22) 1.60]	[0.95 (1.32) 1.86]	[0.95 (1.33) 1.84]
Bolivia	[0.59 (0.83) 1.17]	[0.34 (0.66) 1.05]	[0.28 (0.66) 1.05]
Brazil	[0.62 (0.95) 1.36]	[0.60 (0.95) 1.37]	[0.66 (0.95) 1.34]
Chile	[0.63 (0.88) 1.19]	[0.55 (0.73) 1.03]	[0.52 (0.73) 1.03]
Colombia	[0.57 (0.91) 1.31]	[0.61 (0.95) 1.43]	[0.61 (0.95) 1.44]
Costa Rica	[0.56 (0.85) 1.34]	[0.20 (0.54) 1.12]	[0.21 (0.55) 1.12]
Domin. Rep.	[0.13 (0.65) 1.14]	[0.27 (0.57) 0.98]	[0.29 (0.56) 0.98]
Ecuador	[0.19 (0.74) 1.35]	[0.33 (0.64) 1.27]	[0.24 (0.66) 1.26]
Guatemala	[0.96 (1.20) 1.55]	[0.89 (1.21) 1.67]	[0.91 (1.19) 1.64]
Jamaica	[0.69 (0.91) 1.23]	[0.81 (1.05) 1.37]	[0.79 (1.04) 1.35]
Mexico	[0.77 (1.02) 1.39]	[0.59 (0.85) 1.32]	[0.56 (0.85) 1.32]
Panama	[0.33 (0.54) 0.83]	[0.51 (0.64) 0.83]	[0.49 (0.63) 0.83]
Paraguay	[0.72 (0.94) 1.35]	[0.81 (1.00) 1.31]	[0.79 (1.00) 1.30]
Peru	[0.30 (0.59) 1.04]	[0.42 (0.64) 1.09]	[0.27 (0.61) 1.09]
Trin. & Tob.	[0.87 (1.09) 1.48]	[1.10 (1.31) 1.68]	[1.11 (1.32) 1.70]
Uruguay	[0.76 (1.10) 1.52]	[0.85 (1.27) 1.74]	[0.85 (1.27) 1.74]
Venezuela	[0.55 (0.96) 1.62]	[0.82 (1.16) 1.73]	[0.81 (1.16) 1.73]

Notes: The d parameter is estimated for three alternative specifications: Model 1: no regressors Model 2: with Intercept and Model 3: with intercept and linear time trend. Bold figures indicate where the unit root (i.e., $d = 1$) can be rejected at the 5% level. The values in parentheses refer to the 95% confidence band.

V. Concluding remarks

This paper investigates the mean reverting or unit root behavior of unemployment rates in 18 Latin American countries for the time period 1970 to 2009. We use time series methods to test for mean reversion of unemployment rates and its approximation to NRU. The tests we employ consider the possibility of one and two structural changes in order to account for significant macroeconomic changes experienced by the economies. Therefore, homogeneity is not assumed to exist among countries and specific break dates are endogenously determined for each country. This methodology seems to be suitable because of the macroeconomic instability experienced by the Latin American economies during the period examined. In addition, we estimate the order of integration of unemployment rates using long range dependence techniques, in particular, allowing for fractional degrees of differentiation.

Our results show that when endogenous structural changes are taken into account, 16 out of the 18 Latin American countries exhibit mean reverting behavior. As a consequence, our findings support the structuralist hypothesis. Furthermore, we find evidence of approximation of mean reverting unemployment rates to NRU for three countries: Chile, Costa Rica and Guatemala. Finally, when we estimate the order of integration from a fractional viewpoint, we find evidence supporting the hysteresis hypothesis, emphasizing the importance of including breaks to describe the instability of the Latin American economies.

Appendix

Data sources: Banco Central República Dominicana; Bloomberg Professional Database; Contraloría General de la República; Dirección de Estadística y Censo “Panamá en cifras 1980-2002”; Instituto Nacional de Estadística y Geografía de México; International Labour Organization (ILO), LABORSTA; International Monetary Fund (IMF), World Economic Outlook Database April 2010; Inter-American Development Bank (IDB), Latin American and Caribbean Macro Watch Database August 2010; Organisation for Economic Co-operation and Development (OECD), OECD, Stat; United Nations, ECLAC, CEPASTAT, Data Bases and Statistical Publications, Economic Commission for Latin America and the Caribbean; The World Bank Group, World dataBank, 2010.

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