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Economic Growth and Convergence in Latin America, 1950-2010

Abstract

Latin America's long-run economic growth is dealt with to prove conditional convergence in per capita GDP for two types of leading economies. Mixed empirical evidence in favor of economic convergence is found for the period 1950-1990, while conditional convergence toward both a region's average and the US economy is shown to exist in the period 1990-2010. The possibility for units to exhibit cross-section dependency in heterogeneous panels is taken into account by the second generation tests here applied.

Keywords: Econometric models, economic growth, Latin American economies, United States, per capita GDP.
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1. INTRODUCTION

Latin America's (LA) long-run economic growth can be divided into at least two clearly identifiable subperiods. The first of these corresponds to the years from 1950 to 1980, known as the golden years, when it is generally considered that LA was one of the most developed regions outside the industrial world (Elson, 2005), with economic potential very similar to that of Spain, Italy and South Korea (Barboni and Treibich, 2010). Nonetheless, everything points to the fact that this potential could not be consolidated due to political, religious and quality of human capital, factors which led to a process of divergence from the referred economies (Barboni and Treibich, 2010).

The crisis of 1981-1982 started the so-called *lost decade* in LA, characterized by slow growth. In the nineties average growth was modest, while over the following ten years (2000-2010) higher growth combined with greater variability was observed (Solimano and Soto, 2003).

For this last phase of long-run growth in LA, discussion on the processes of convergence or divergence draws different conclusions. The works of Astorga, Bergés and Fitzgerald (2005), and Astorga (2010) conclude that if the behavior of six LA countries (Argentina, Brazil, Chile, Colombia, Mexico and Venezuela) is analyzed in the last century (1900-2000), it is found that they tend toward economic and social convergence mainly due to the similarity in their patterns of industrialization, urbanization and public provision. These authors also state that the remaining countries of the region did not experience a process of convergence and that the main sources of economic growth are concentrated in the accumulation of investment and human capital. Moreover, Martín-Mayoral (2010) studies the disparities across South American, Central American (excluding Belize) and North American (excluding the United States and Canada) countries during the period 1950-2008. The results show a slow convergence process up to 1985, subsequently a process of accelerated conditional convergence with different steady states is observed, which is mainly explained by the rate of saving to investment, public spending and trade liberalization.

For a specific period, from 1980 to 2010, characterized by moments of low growth, debt crises, structural reforms, paradigm shifts and globalization, Barrientos (2007) suggests it is much more appropriate to talk of at least three groups of countries: the group of countries with *good institutions* (composed of Argentina, Brazil, Chile, Colombia, Costa Rica, Mexico and Uruguay), that suffered serious consequences of the debt crises but then tend toward higher growth rates; the *painful* group with weak institutions (composed of Bolivia, Ecuador, Guatemala, Honduras, Nicaragua, Paraguay, Peru, El Salvador and Venezuela), which exhibit bad economic and social results and, finally, the *vulnerable* (composed of the Bahamas, Barbados, Belize, Cuba, Dominica, Dominican Republic, Guyana, Haiti, Jamaica, Panama, Puerto Rico, St. Kitts and Nevis, Santa Lucia, Saint Vincent and the Grenadines, and Trinidad and Tobago). From the point of view of sigma convergence, there are no data to conclude convergence or divergence across all the countries, although for the *good institutions* group a process of convergence was found until 1990 and divergence after that year. Several countries from the *painful* group exhibit high per capita GDP dispersion levels and negative economic growth rates. The *vulnerable* group, which is more homogenous and has a very low GDP dispersion, maintained periods of convergence during 1970-1995, divergence in 1995-1999, and convergence again after that. Barrientos's (2007) results for the *good institutions* group show absolute and conditional convergence of 2% and 3.6%, respectively, for the period 1980-2010; the *painful* group exhibited absolute convergence of 0.7% and conditional one of 5.7%, while the *vulnerable* group converged in absolute terms at 6% over the same period. The conclusion is that external factors were determinant of the path of convergence among the countries in each group.

Holmes (2006), Cermeño and Llamosa (2007), Escobari (2011), Rodríguez et al. (2012) utilize the concept and methods of stochastic convergence, unit roots or cointegration to study convergence processes comparing leading economies inside and outside LA. Holmes (2006) evaluates the convergence hypothesis for eight Latin American countries in the period 1900-2003 using the Markov methodology of regime switching and defines for it the concepts of partial convergence (change from a steady regime to another non-stationary) and varied convergence (degree of persistence). By applying this methodology, he found the existence of a switching from a stationary or convergence process to another non-stationary or divergent process, which can also be identified as the existence of two different stationary regimes. Cermeño and Llamosa (2007) use the approach of Bernard and Durlauf (1995) to analyze possible convergence processes for Argentina, Brazil, Canada, Chile, USA and Mexico for the period 1950 to 2000. Neither the restricted nor the unrestricted versions (or absolute and conditional convergence, respectively) of the cointegration analysis for the comparison between LA countries and the USA show strong evidence of convergence, although in the cases comparing Argentina-USA, Chile-USA and Brazil-Argentina the results show weak evidence.

The work of Escobari (2011) for 19 countries and the period 1945 to 2000 applies unit root analysis and compares pairs of countries using the same methodology employed by Bernard and Durlauf (1995). Thus, it finds a process of convergence between the Dominican Republic and Paraguay. When groups of countries were considered it found more evidence of convergence across the economies of Central America and the Caribbean than across the economies of South America. Finally, the study of Rodríguez et al. (2012) on the hypothesis of convergence toward the economy of the USA for 17 Latin American countries during the period 1970 to 2010 using unit root tests and panel cointegration finds no evidence of absolute convergence, but does see conditional convergence.

This paper presents an analysis of the path of long-run economic growth of Latin American countries in accordance with the hypotheses of absolute and conditional convergence in per capita GDP with respect to two types of leading economies: a region's average and the USA. To test the convergence hypothesis first and second-generation cointegration and unit root panel tests were applied for the period 1950-2010. The second-generation tests, such as those of Maddala and Wu (1999) and Pesaran (2007) have the advantage of eliminating root homogeneity assumptions and independence between the cross-section units, assumptions upheld by the majority of first generation tests, e.g. those of Pesaran and Smith (1995), Pesaran (1997) and Pesaran et al. (1999). The results obtained show mixed and inconclusive evidence for economic convergence in the period 1950-1990 and of conditional convergence toward the region's average and to the USA during the 1990-2010 period of trade liberalization.

The paper is organized as follows. Section 2 broadly outlines the tests employed and presents a brief review of the empiric literature. Section 3 describes the econometric methodology employed and the data. Section 4 gives the results of the econometric tests carried out and, finally, Section 5 states the conclusions.

2. REVIEW OF THE LITERATURE

2.1 Specification of Absolute and Conditional Convergence Tests

Baumol, Nelson and Wolff (1994) make a classification of the different interpretations of convergence most used in the specialized literature: homogenous, catch-up, gap, absolute convergence, explained convergence, asymptotic convergence and limit convergence. All these interpretations can be linked to the conclusions of the neoclassical growth model for closed economies (Ramsey, 1928; Solow, 1956; Cass, 1965; and Koopmans, 1965), which predict that the growth rate trend of the capital-labor ratio (K/L) is inversely related to its initial level (Galindo and Malgesini, 1994).

In response to the many criticisms of the endogenous growth theory, Barro and Sala-i-Martin (2004), and Mankiw, Romer and Weil (1992) substituted the concept of Baumol's absolute convergence with that of conditional convergence, taking into account the international economic consistency of the nineties. The first interpretation of this concept is that the existence of convergence does not only depend on the capital-labor ratio, but also on other economic conditions (human capital, social capital, technology, policies, etc.), which can drive the process of convergence across countries. For Sala-i-Martin (1997), the conditional convergence hypothesis also allows for understanding the conditions that economies should fulfill in order to be able to group them into convergence clubs.

The convergence concept commonly employed in most studies is that of $\beta-$ convergence. It is said that there is absolute $\beta-$ convergence across countries if there is a negative relation between the growth rate of per capita income and the initial value of per capita income, which implies that the poorest countries grow at a faster rate than rich countries in such way as to arrive at the same long-run equilibrium.

In the nineties, most studies concentrated on the relation between the growth rate of income per capita and different standards of living measures in cross section to investigate the growth process. These studies were based on the following model:

$$g_i = \alpha X_i + \beta y_{i0} + \varepsilon_i, \tag{1}$$

where g_i is the country's growth rate, y_{i0} is the value of the country variable at the start of the period studied, X_i includes variables by country to control for the specific effects of each of them and ε_i is the error term. The initial value of variable y_{i0} is included in order to test the convergence hypothesis (Durlauf, 2000). Thus, if the value of β is negative in Equation 1, there is $\beta-$ convergence. In terms of Equation 1, one way of testing the absolute, or unconditional, version is by excluding each country's specific control variables, verifying that β is negative, while a conditional convergence test is carried out by including the X_i control variables (Barro and Sala-i Martin, 2004).

Different studies have criticized the application of cross-section growth models to prove absolute or conditional convergence and have proposed panel methodologies compatible with the inferences of exogenous and endogenous models (Bond et al., 2010).[1] For instance, Bernard and Durlauf (1995) state that once this analysis is applied to a group of country data through an appropriately specified model with multiple steady-states a negative β coefficient for the total sample can be attributed to a subsample of those countries that converges to the specific steady-state group. In addition, Quah (1993, 1996a, 1996b, 1997) suggests that these tests for the convergence hypothesis suffer from Galton's fallacy, i.e., once we regress growth rates to their initial levels, a negative β coefficient is due to a regression toward the mean, which does not necessarily imply convergence.

The vast majority of studies that have used Equation 1 have tended to ignore underlying patterns of heterogeneity in the data by using an identical regression model for all countries in the sample. Some of them use dummies for Latin America or sub-Saharan Africa in order to take into account the differences in the growth process for those groups of countries. However, this is not enough to capture the statistical measures of the clubs in the group of data. In this regard, Bernard and Durlauf (1994 and 1995) evaluate the possibility of convergence using the following model:

$$y_{it} = \alpha_{ij} + \beta y_{jt} + \varepsilon_{ijt}, \quad (2)$$

where y_{it} is per capita income of the country in question, y_{jt} is per capita income of the leading or reference economy and a_{ij} is a

[1] In the same way as Bond et al. (2010), in this paper we use the estimators proposed by Pesaran and Smith (1995), Pesaran (2007), and Pesaran et al. (1999). The difference between the specification of Bond et al. (2010) and ours lies in the fact that he aims to analyze how capital accumulation affects growth, he does not carry out estimates for Latin America and does not use the referred estimators to test convergence, while the specification used here is applied to the convergence test for Latin American countries.

constant that denotes permanent differences between the two economies (Cermeño and Llamosas, 2007). If convergence exists, the differences between two countries will tend to decrease over time, i.e., it requires that $\alpha_{ij} = 0$ in order for the differences to be completely eliminated (absolute convergence). If the latter is not fulfilled, it will tend toward a different determined level (conditional convergence). Thus, fulfillment of the absolute convergence hypothesis requires that $\beta = 1$ and $\alpha_{ij} = 0$. Therefore, if $\alpha_{ij} \neq 0$ there is evidence of conditional convergence.

If absolute convergence is fulfilled, a simple and direct way of proving it would be to obtain the difference between per capita income of the country in question and per capita income of the leading or reference economy, both in natural logarithms:

$$y_{it} - y_{jt} = \varepsilon_t . \tag{3}$$

Based on this series, the null hypothesis of non-convergence can be written as:

$$H_0 : y_{it} - y_{jt} = I(1), \quad \forall i = 1, \ldots, N. \tag{4}$$

The above can be carried out through unit root tests. This version of the test is known as the restricted version. According to Cheung and García (2004), testing the null hypothesis set out in Equation 4 can bias the results toward acceptance of the non-convergence hypothesis due to the reduced power of the unit root tests. Cheung and García therefore propose evaluating the convergence hypothesis in the following way:

$$H : y_{it} - y_{jt} = I(0), \quad \forall i = 1, \ldots, N. \tag{5}$$

If it is not possible to reject Equations 4 and 5 at the same time, the data cannot provide evidence for accepting or rejecting the convergence hypothesis.

As for the unrestricted version of the test, it is not assumed a priori and the model of Equation 2 is employed for estimating parameters α_{ij} and β. In this version of the test, the non-convergence hypothesis is evaluated by applying the unit root test to the errors estimated in this model. With this approach, the null hypothesis states that there is no cointegration between income per capita of the country studied relative to the leading economy. This version of the test also has the advantage that it is possible to determine if the constant is significant and, therefore, can show evidence of conditional convergence as well as verify whether the vector $(1,-1)$ of the restricted model is fulfilled or not.

The test defined in Equation 3 for demonstrating the convergence hypothesis between two countries can be extended for a panel model that includes a group of countries in the following way:

6 $$D_1 y_{it} = y_{it} - y_{lt} \ ,$$

where y_{it} is the income per capita of country i at time t, and y_{jt} is the income per capita of the leading country at time t, both in algorithms. Thus, the convergence hypothesis between two countries can be tested through panel integration and cointegration analysis when the income per capita of both countries are not stationary (Díaz et al., 2009), which can be carried out applying different panel unit root tests to the group of series resulting from Equation 6.

A less restrictive version of Equation 6 is an extension of Equation 2 to the panel model as follows:

7 $$\begin{aligned} y_{it} &= \alpha_i + \beta y_{jt} + v_{it} \\ D_2 y_{it} &= y_{it} - \alpha_i - \beta y_{jt} = v_{it} \end{aligned} .$$

Thus, Model 7 gives an estimate of the slope parameter for the panel as a whole, which allows for testing the convergence hypothesis for the group of countries included in the panel given that, as will be shown below, according to the estimation methodology of Pesaran, Shin and Smith (1999) for cointegrated, panels it is possible to estimate parameter β for the panel as a whole and a speed of adjustment coefficient for each of the units considered. If the GDP per capita of countries included in the sample and that of the leading economy are cointegrated it will therefore also be possible to allocate a homogeneous long-run relation for the whole panel and the way in which it responds to each of the units in such relation.

2.2 Literature on Convergence

Evans (1997) demonstrates that when control variables are introduced into Equation 1, although these control 90% of the variance of steady-state GDP per capita values, the probability limit of the least squares estimator of the initial income coefficient (which is the convergence indicator) is approximately equal to half its true value. For this reason, it is not advantageous to make inferences employing this type of regressions.

Among the studies that have employed time series techniques, the following stand out: Linden (2000) studies the OECD group of countries by applying multivariate augmented Dickey-Fuller (ADF) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) unit root tests by pairs, finding convergence only for Norway, Sweden and UK. Amable and Juillard (2000) apply the same tests for a sample of 53 countries, finding that the ADF test almost never confirmed convergence except in the cases of Denmark and Germany. Camarero, Flôres and Tamarit (2002) study countries in the Mercosur through multivariate ADF tests and panel models, finding evidence of convergence for some countries. Easterly, Fiess and Lederman (2003) analyze the convergence hypothesis between Mexico and USA with Johansen's test and find evidence of conditional convergence. Finally, Cheung and Pascual (2004) analyze the case of the Group of Seven (G7) through multivariate ADF tests and panel studies, showing evidence that the multivariate ADF test does not confirm convergence.

Cermeño and Llamosas (2007) employ the restricted and unrestricted version of Model 2 to test the convergence hypothesis for GDP per capita across six emerging countries with respect to the USA. To do this they implement the Gregory and

Hansen (1996) approach of cointegration under possible structural change. Their results suggest that in most cases there is no evidence to support convergence under structural change, and that the gaps of income per capita between the countries considered relative to the USA are consistent with a non-convergence processes.

3. ECONOMETRIC METHODOLOGY AND DATA

3.1 Panel Unit Root Tests

Panel unit root tests are similar, but not identical, to the unit root tests carried out on any series in particular. This section briefly describes the two panel unit roots tests employed in this paper.

Maddala and Wu (1999, hereafter, MW), sustain that various difficulties emerge in the Im-Pesaran-Shin (IPS) test because it relaxes the homogeneity assumption through the unit roots.[2] MW suggest using a Fisher type test, which is constructed based on a combination of p values (denoted by π_i) of the unit root test statistic in each of the cross sections. The MW test statistic, λ, is given by:

8 $$\lambda = -2\sum_{i=1}^{N} \ln \pi_i \text{ ,}$$

which is distributed as an $\chi^2(2N)$ under the null hypothesis of cross-sectional independence. In the same way, Breitung (2000) argues that IPS tests lose power by including individual trends. One of the advantages of the Maddala y Wu (1999) test is that its value does not depend on the different lags included in the individual regressions for obtaining each of the ADF statistics.

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[2] The homogeneity assumption implies that all the individual roots are equal, meaning it has to be assumed $(\alpha_i = \alpha = 0, \forall i)$, while the heterogeneity assumption indicates that all the roots are different, but $(\alpha_i = 0, \forall i)$ must be fulfilled for convergence to exist.

As in the case of most ADF tests, both IPS and MW tests rest on the assumption that cross section units are independent. The second generation panel unit root test we employ in this paper is that of Pesaran (2007),[3] who proposed the CIPS test, the test statistic of which is the individual cross section mean of the *t* statistics of individual ordinary least square coefficients of y_{it-1} in regression CADF (cross-sectionally ADF) for each unit in the panel. The CADF regressions correspond to the ADF test that incorporates the cross-section averages of lagged levels and first-differences of the individual series. Thus, the regressions are of the following type:

$$\Delta y_{it} = \alpha_i y_{it-1} + \lambda_i \overline{y}_{t-1} + \sum_{j=1} \eta_{ij} \Delta \overline{y}_{t-j} + \sum_{j=1}^{p} \delta_{ij} \Delta y_{i,t-j} + e_{it} \quad (9)$$

In this test, the null hypothesis $(\alpha_i = 0, \forall i)$ is that all units in the panel possess a unit root, as opposed to the variance stationarity alternative where at least some of them possess one.

3.2 Kao (1999) Panel Cointegration Tests

Kao (1999) proposed ADF type tests similar to the standard single equation approach adopted in Engle and Granger's two-step procedure. In the case dealt with here, the procedure consists of estimating the following panel regression model:

$$y_{it} = \alpha_i + \delta_i z_{it} + \beta y_{lt} + \varepsilon_{it}, \quad (10)$$

where it is assumed that y_{it} and y_{lt} are non-stationary and that z_{it} is a matrix of deterministic components. The residuals of this model are used to estimate the following model:

$$\hat{e}_{it} = \rho \hat{e}_{i,t-1} + \upsilon_{it}. \quad (11)$$

[3] This test takes into account the possibility that units in the panel could be dependent.

where $\hat{e}_{it} = \left(y_{it} - \alpha_i - \delta_i z_{it} - \beta y_{lt}\right)$. This case attempts to test the null hypothesis of non-convergence, H_0: ρ=1, in Equation 11, against the alternative hypothesis where y_{it} and y_{lt} are cointegrated, i.e., that H_1: ρ<1. Kao developed four Dickey-Fuller (DF) type tests that only limit the case of fixed effects. Two of Kao's tests assume robust exogeneity of regressors and errors in Equation 10 denoted by DF_p and DF_t, while the other tests, which are non-parametric, make corrections for any endogenous relation and are denoted by DF_p and DF_t. The four tests include non-parametric corrections for the possibility of any serial correlation given that Equation 11 involves an ordinary least squares regression (MCO) of de $\hat{e}_{it}$ over a single lagged value of $\hat{e}_{it}$.

As an alternative, Kao also proposed a test that extends Equation 11 by including lagged differences at residuals. He therefore obtains an ADF version of his test on the existence of serial correlation as part of the regression procedure. All the tests are asymptotically distributed in accordance with standard normal distribution. It is important to point out that the versions of Kao's test impose homogeneity in the β slope coefficient, i.e., it is not allowed to vary across the individuals making up the panel.

3.3 Panel Estimation Methods for Cointegrated Variables

For panel cointegration models the asymptotic properties of regression model coefficient estimators and associated statistical tests are different from those estimated by cointegrated time series models (Baltagi, 2008).

Some of these differences have been revealed in recent works by Kao and Chiang (2000), Phillips and Moon (1999), Pedroni (1999, 2000, 2004), and Mark and Sul (2003). Panel cointegration models are designed for studying long-term relations typically found in macroeconomic and financial data. Such long-term relations are often cited by economic and financial theory, which is the main reason for estimating regression coefficients and testing whether or not they satisfy theoretical restrictions. Phillips and Moon (1999) and Pedroni (2000) propose a fully-modified (FM) estimator, which can be viewed as a generalization of the Phillips y Hansen (1990) estimator, while Kao and Chiang (2000) advance an alternative method based on the dynamic least squares estimator, taking the works of Saikkonen (2001) and Stock and Watson (1993) as a reference.

3.3.1 Group Mean Estimator

To test the convergence hypothesis for Latin American countries we employ the estimators proposed by Pesaran, Shin and Smith (1999), who suggest two different estimators in order to resolve the possible lag attributable to slope heterogeneity in dynamic panels. These are the mean group (MG) and pooled mean group (PMG) estimators.

The MG estimator allows long-term parameters to be obtained for the panel from an average of the long-term parameters in autoregressive distributed lag (ADRL) models for units or individuals (Asteriou and Hall, 2007). For instance, if the ADRL is as follows:

12 $$y_{i,t} = a_i + \gamma_i y_{i,t-1} + \beta_i x_{i,t} + e_{i,t} .$$

Therefore, the long-term parameter, θ_i, for the individual or unit i is:

13 $$\theta_i = \frac{\beta_i}{1-\gamma_i} .$$

The estimators for the whole panel would therefore be given by:

14 $$\hat{\theta} = \frac{1}{N}\sum_{i=1}^{N}\theta_i , \;\; \hat{a} = \frac{1}{N}\sum_{i=1}^{N} a_i . \quad .$$

It is possible to show how with a sufficiently large number of lags the MG estimator provides super consistent estimators for the long-term parameters even when the order of integration of the regressors is equal to one (Pesaran, Shin and Smith, 1999).

The MG estimators are consistent and have normal asymptotic distributions for sufficiently large N and T. Nevertheless, for samples where T is small, the MG estimator is lagged and can lead to erroneous inferences, meaning it should be used with caution in such cases.

3.3.2 Pooled Mean Group Estimator

Pesaran and Smith (1995) show that, unlike static models, pooled heterogeneous dynamic panels generate estimators that are inconsistent even in large samples. Baltagi and Griffin (1997) argue that the benefit in terms of efficient data aggregation outweighs the loss caused by the bias induced by heterogeneity. Pesaran and Smith (1995) observe how it is improbable that dynamic specification is common to all units, while it is at least conceivable that long-run parameters of the model may be common. They propose carrying out the estimate by averaging the estimated parameters individually or pooling the long-term parameters where the data allows it, and estimating the model as a system. Pesaran, Shin and Smith (1999) refer to this method as the pooled mean group (PMG) estimator, which combines the efficiency of the pooled estimate while avoiding the problems of inconsistency arising from pooling dynamic heterogeneous relations.

The PMG sits in between the MG (where both slopes and intercepts are allowed to vary across units) and the classic fixed effects model (where slopes are fixed and intercepts vary across units). Calculation of the PMG estimator only restricts long-term coefficients to be the same across units, while allowing short-term coefficients to vary across them.

More precisely, the unrestricted specification of the ADRL system of equations is as follows:

$$y_{it} = \mu_i + \sum_{j=1}^{p} \lambda_{ij} y_{i,t-1} + \sum_{j=0}^{p} \lambda \delta'_{ij} x_{i,t-j} + \varepsilon_{it} \,, \tag{15}$$

where $x_{i,t-j}$ is a vector of explanatory variables and μ_i represents the fixed effects. In principle the panel can be unbalanced and p and q may vary across units. This model can be reparametrized as a vector error correction model (VECM):

$$\Delta y_{it} = \theta_i \left(y_{i,t-1} - \beta' x_{i,t} \right) + \sum_{j=1}^{p-1} \gamma_{ij} \Delta y_{i,t-j} + \sum_{j=1}^{q-1} \phi'_{ij} \Delta x_{i,t-j} + \varepsilon_{it} , \quad (16)$$

where the θ_i are short-term parameters for each of the units, and β is the short-term parameter common to all of them. The estimate can be carried out by MCO, imposing and testing cross section restrictions on β. Nevertheless, this procedure could be inefficient as it ignores contemporary residual covariance. Given the latter, an estimator could be calculated with Zellner's SUR method, which is a type of feasible generalized least squares estimation. However, the SUR procedure is only possible if $N < T$, the reason why Pesaran, Shin and Smith (1999) suggest employing the maximum likelihood method.

4. RESULTS

First, we look into the possible presence of unit root in the difference between each country's income per capita relative to each of the two indicators considered as *leading economy:* GDP per capita of the USA and average GDP per capita of the region. The latter calculation includes GDP per capita of the USA. To this end, we apply the tests of Maddala and Wu (1999) and of Pesaran (2007), with different lags to Dy_{it}, as established in Equation 6. Tables 1 and 2 show the results of the root test for different periods and the sample as a whole.

In the case of the difference between the GDP per capita of each country as compared to that of USA, the MW and Pesaran tests carried out with and without trend (see Table 1) show that for both the total sample and the first subperiod it is not possible to reject the unit root null hypothesis in any case in the panel considered, meaning that in these cases there are

Table 1

PANEL UNIT ROOT TESTS FOR $D_l y_{it} = y_{it} - y_{lt}$, RELATIVE TO THE USA: TOTAL SAMPLE AND BY PERIODS

	Maddala and Wu (1999)				*Pesaran (2007)*			
	Without trend		*With trend*		*Without trend*		*With trend*	
Lags	χ^2	*p value*	χ^2	*p value*	χ^2	*p value*	χ^2	*p value*
				Total sample (1951-2010)				
0	19.85	[0.97]	10.87	[1.00]	0.27	[0.61]	1.61	[0.95]
1	22.96	[0.92]	18.27	[0.99]	0.04	[0.52]	0.48	[0.68]
2	25.15	[0.86]	23.72	[0.91]	0.49	[0.69]	0.78	[0.78]
3	32.02	[0.57]	19.90	[0.97]	0.74	[0.77]	0.99	[0.84]
4	28.77	[0.72]	24.60	[0.88]	1.67	[0.95]	2.22	[0.99]
				First period (1951-1990)				
0	13.56	[0.99]	10.86	[1.00]	2.16	[0.99]	1.31	[0.91]
1	16.03	[0.99]	17.91	[0.99]	2.22	[0.99]	0.71	[0.76]
2	22.32	[0.94]	14.44	[0.99]	2.90	[0.99]	1.84	[0.97]
3	22.10	[0.94]	23.75	[0.91]	3.57	[1.00]	2.01	[0.98]
4	22.25	[0.94]	20.57	[0.97]	4.23	[1.00]	3.16	[0.99]
				Second period (1990-2010)				
0	35.42	[0.40]	7.64	[1.00]	−1.34	[0.09]	−0.29	[0.39]
1	39.77	[0.23]	11.30	[1.00]	−2.58	[0.01]	−3.43	[0.00]
2	42.09	[0.16]	11.05	[1.00]	−1.78	[0.04]	−5.07	[0.00]
3	37.60	[0.31]	8.45	[1.00]	−1.33	[0.09]	−4.70	[0.00]
4	52.12	[0.02]	17.82	[0.99]	−0.93	[0.18]	−2.30	[0.01]

Note: Numbers in parenthesis are *p* values for the lags included in each test.
Source: Own elaboration.

no signs of convergence with respect to this indicator in the periods analyzed. For the second subperiod the MW test without trend and with four lags, and Pesaran's test without trend, one and two lags and trend for lags one to four, reject the unit root null hypothesis. This suggests some indications of stationarity in the difference between the GDP per capita of each

Table 2

PANEL UNIT ROOT TESTS FOR $D_l y_{it} = y_{it} - y_{lt}$ RELATIVE TO REGION'S AVERAGE: TOTAL SAMPLE AND BY PERIODS

	Maddala and Wu (1999)				*Pesaran (2007)*			
	Without trend		*With trend*		*Without trend*		*With trend*	
Lags	χ^2	*p value*	χ^2	*p value*	χ^2	*p value*	χ^2	*p value*
				Total sample (1951-2010)				
0	44.54	[0.16]	31.18	[0.70]	0.59	[0.72]	1.03	[0.85]
1	39.95	[0.30]	31.28	[0.69]	0.23	[0.59]	−0.23	[0.41]
2	31.34	[0.69]	22.08	[0.97]	1.02	[0.85]	0.40	[0.66]
3	28.82	[0.80]	17.95	[0.99]	1.52	[0.94]	0.43	[0.67]
4	26.40	[0.88]	17.32	[0.99]	2.23	[0.99]	1.40	[0.92]
				First period (1951-1990)				
0	35.44	[0.50]	30.15	[0.74]	3.03	[0.99]	2.14	[0.98]
1	28.07	[0.83]	33.82	[0.57]	3.04	[0.99]	1.49	[0.93]
2	25.91	[0.89]	23.16	[0.95]	4.03	[1.00]	2.58	[0.99]
3	19.71	[0.99]	22.19	[0.97]	4.89	[1.00]	2.97	[0.99]
4	15.33	[0.99]	26.87	[0.87]	5.42	[1.00]	4.33	[1.00]
				Second period (1990-2010)				
0	64.06	[0.00]	24.23	[0.93]	−0.19	[0.43]	−0.85	[0.20]
1	56.96	[0.02]	42.55	[0.21]	−1.10	[0.14]	−3.36	[0.00]
2	42.07	[0.23]	29.58	[0.77]	0.10	[0.54]	−1.47	[0.07]
3	44.47	[0.16]	27.99	[0.83]	−0.43	[0.33]	−0.17	[0.43]
4	45.43	[0.14]	36.20	[0.46]	−1.49	[0.07]	0.57	[0.72]

Note: Numbers in parenthesis are *p* values for the lags included in each test.
Source: Own elaboration.

Latin American country and that of the USA and, therefore, of convergence between both indicators for the subperiod corresponding to trade liberalization.

With respect to MW and Pesaran tests, with and without trend, on the differences between each country's GDP and average GDP per capita for the region, they show a similar result for the total sample and for the first subperiod given that it is not possible in any case to reject the unit root null hypothesis in the panel for that variable (see Table 2).

For the second subperiod the MW test without trend, without lags and with one lag, and the Pesaran test with trend, with one and two lags, allow for rejecting the unit root hypothesis, which suggests the presence of some indications of stationarity in the difference of each Latin American country's GDP per capita relative to the region's average and, therefore, of convergence between both indicators for the second subperiod 1990-2010. The same can be said for the tests implemented with the difference between GDP per capita of countries in the region and that of USA.

Thus, both indicators constructed for proving the restricted version of the test show evidence that there are indications of stationarity in said indicators only during the second subperiod. This implies that the process of convergence between the Latin American countries and the USA, and the region's average was only seen in the second subperiod corresponding to the phase of trade liberalization.

Once the possible presence of convergence was verified in the total sample and the subperiods according to the restricted version of the test, we applied panel unit root tests in order to examine the possible presence of unit root in the natural logarithm of GDP per capita for countries of the region. And, if it exists, proceed to carry out panel cointegration tests of this indicator with respect to per capita GDP of the USA and average GDP per capita of the region. The results of the panel unit root tests applied to the natural logarithm of GDP per capita of the countries of the region considered are shown in Table 3.

As can be seen in Table 3, MW unit root tests do not allow for rejecting the unit root null hypothesis in the natural logarithm of GDP per capita of any of the countries considered. However, Pesaran's test in some cases shows that said hypothesis is rejected, mainly for the total sample and the first subperiod, when the test is specified with few lags. Meanwhile, in the majority of cases, Pesaran's test with trend cannot reject the unit root hypotheses for this variable. Notwithstanding the aforementioned, in the following analysis we assume that per capita GDP

Table 3

PANEL UNIT ROOT TESTS OF MADDALA AND WU (1999), AND PESARAN (2007) FOR YIT

TOTAL SAMPLE AND BY PERIODS

	Maddala and Wu (1999)				*Pesaran (2007)*			
	Without trend		*With trend*		*Without trend*		*With trend*	
Lags	χ^2	*p value*	χ^2	*p value*	χ^2	*p value*	χ^2	*p value*
Total sample (1951-2010)								
0	21.54	[0.95]	12.52	[1.00]	−1.77	[0.04]	−0.50	[0.31]
1	16.12	[0.99]	17.16	[0.99]	−2.33	[0.01]	−1.31	[0.10]
2	18.43	[0.99]	15.95	[0.99]	−1.83	[0.03]	−0.83	[0.20]
3	19.81	[0.98]	17.41	[0.99]	−1.45	[0.07]	−0.14	[0.44]
4	19.55	[0.98]	17.78	[0.99]	−0.32	[0.37]	1.45	[0.93]
First period (1951-1990)								
0	31.04	[0.61]	10.72	[1.00]	−2.29	[0.01]	−0.43	[0.34]
1	27.17	[0.79]	16.00	[0.99]	−2.49	[0.01]	−0.97	[0.17]
2	24.41	[0.89]	15.24	[0.99]	−2.13	[0.02]	−0.47	[0.32]
3	29.01	[0.71]	18.71	[0.98]	−1.08	[0.14]	0.85	[0.80]
4	26.70	[0.81]	16.15	[0.99]	−0.08	[0.47]	2.03	[0.98]
Second period (1990-2010)								
0	16.57	[0.99]	24.73	[0.88]	−0.33	[0.37]	−0.18	[0.43]
1	16.88	[0.99]	35.51	[0.40]	−2.28	[0.01]	−3.32	[0.00]
2	8.30	[1.00]	37.72	[0.30]	−0.80	[0.21]	−2.12	[0.02]
3	8.42	[1.00]	25.15	[0.87]	−1.17	[0.12]	−1.50	[0.07]
4	9.96	[1.00]	34.65	[0.44]	−0.66	[0.25]	−0.43	[0.33]

Notes: Numbers in parenthesis are *p* values for the lags included in each test.
Source: Own elaboration.

Table 4

PANEL COINTEGRATION TESTS OF KAO (1999)
TOTAL SAMPLE AND SUBPERIODS
H0: NO COINTEGRATION

Total sample (1951-2010)		***First period (1951-1990)***		***Second period (1990-2010)***	
Statistics	*Prob.*	*Statistics*	*Prob.*	*Statistics*	*Prob.*
		Relative to USA			
−1.24	[0.11]	−0.29	[0.39]	−2.15	[0.02]
		Relative to region's average			
−1.30	[0.10]	−0.63	[0.27]	−3.42	[0.00]

Note: Testing conducted by incorporating individual intercepts.
Source: Own elaboration.

of the Latin American countries considered has an order of integration equal to 1.

The results of the panel cointegration test of Kao (1999) for GDP per capita of Latin American countries and that of the USA and a region's average, both in turn considered as *leading economy*, are presented in Table 4. As can be seen, evidence of cointegration between the two indicators only exists in the second subperiod, given that for both the total sample as well as for the first subperiod it is not possible to reject the null hypotheses of non-cointegration between GDP per capita of Latin American countries and GDP per capita of the *leading economy*.

Taking into account these results, we estimate the β convergence coefficient of the restricted version of the test between GDP per capita of countries of the region and the leading economy. The results are shown in Table 5.

Table 5

RESULTS OF PMG, MG AND DFE ESTIMATORS FROM PESARAN, SHIN AND SMITH (1999)

	Total sample (1951-2010)		*First period (1951-1990)*		*Second period (1990-2010)*	
			Relative to USA			
$\widehat{\beta}_{PMG}$	0.66	[0.00]	0.10	[0.32]	0.90	[0.00]
$H_0: \widehat{\beta}_{PMG} = 1$	29.07	[0.00]	85.89	[0.00]	1.17	[0.28]
$\widehat{\beta}_{MG}$	0.61	[0.00]	0.21	[0.62]	1.00	[0.08]
$H_0: \widehat{\beta}_{MG} = 1$	8.32	[0.00]	3.59	[0.06]	0.00	[0.99]
$\widehat{\beta}_{DFE}$	0.60	[0.00]	0.14	[0.57]	1.24	[0.00]
$H_0: \widehat{\beta}_{DFE} = 1$	10.52	[0.00]	11.71	[0.00]	0.92	[0.34]
Hausman tests						
PMG vs MG	0.17	[0.68]	0.06	[0.81]	0.03	[0.86]
MG vs DFE	0.00	[0.99]	0.00	[0.99]	0.00	[0.99]
			Relative to region's average			
$\widehat{\beta}_{PMG}$	0.97	[0.00]	0.74	[0.00]	0.83	[0.00]
$H_0: \widehat{\beta}_{PMG} = 1$	0.42	[0.52]	30.43	[0.00]	27.31	[0.00]
$\widehat{\beta}_{MG}$	0.94	[0.00]	0.81	[0.00]	1.26	[0.00]
$H_0: \widehat{\beta}_{MG} = 1$	0.13	[0.72]	0.42	[0.52]	1.21	[0.27]
$\widehat{\beta}_{DFE}$	0.92	[0.00]	0.89	[0.00]	1.14	[0.00]
$H_0: \widehat{\beta}_{DFE} = 1$	0.30	[0.58]	0.45	[0.50]	1.42	[0.23]
Hausman tests						
PMG vs MG	0.04	[0.84]	0.06	[0.81]	2.89	[0.09]
MG vs DFE	0.00	[0.99]	0.00	[0.99]	0.00	[0.99]

Note: Numbers in parenthesis are *p* values.

The estimates show that when GDP per capita of the USA is taken as leading economy, the coefficients estimated with PMG, MG and DFE estimators for the total sample and the first subperiod were much less than one. Besides the fact that in all cases the Hausman tests show that from the PMG and MG estimators, the PMG estimator is the most efficient with the null hypothesis and both cases reject the null hypothesis that the true parameter is equal to one. On the other hand, the results are very different for the second subperiod of the sample where PMG and MG estimators were equal to 0.90 and 1.00, respectively. The first of these is significant at 1% and the second at 10%. Furthermore, it was not possible to reject the hypothesis that the $\widehat{\beta}$ coefficient is equal to one for either indicator. Thus, the presence of panel cointegration between both variables according to the test of Kao (1999) for the second subperiod, and the fact that it is not possible to reject the hypothesis that the parameter estimated by PMG is equal to one (PMG = 1) for that subgroup shows robust evidence for convergence of Latin American countries toward the USA in the second subperiod. This result is also compatible with that found with the restricted version of the test.

On the other hand, estimates carried out to test for β convergence taking a region's average as leading economy revealed that the PMG estimator of β is very close to one for the whole sample. It is not possible in this case to reject the null hypothesis that said parameter is equal to 1 either. In the same way as in the previous case where GDP per capita of the USA is taken as the leading economy, when the region's average per capita GDP is taken as leading economy Hausman's tests show that in every case the PMG estimator is more efficient than the MG estimator.

As for estimates carried out by subperiods, taking a region's average as leading economy, although all the indicators were statistically significant, in the case of estimates through the PMG it was not possible to accept the null hypothesis that this coefficient is equal to one. For this reason, we do not find evidence of convergence toward the region's average by subperiods despite the fact that we do find evidence of this for the period as a whole.

Table 6

SPEED OF ADJUSTMENT COEFFICIENTS (INDIVIDUAL AND PANEL) ESTIMATED THROUGH THE PMG ESTIMATOR OF IM, PESARAN AND SHIN (1999) RELATIVE TO USA

	Total sample			*First period*			*Second period*		
	$\hat{\theta}_i$	*Std. error*	*z*	$\hat{\theta}_i$	*Std. error*	*z*	$\hat{\theta}_i$	*Std. error*	*z*
Argentina	−0.08	0.06	−1.46	−0.08	0.06	−1.48	−0.03	0.11	−0.28
Bolivia	−0.06	0.03	−2.47	−0.21	0.09	−2.43	−0.01	0.06	−0.23
Brazil	−0.05	0.02	−2.79	−0.03	0.02	−2.17	−0.08	0.09	−0.84
Chile	0.01	0.03	0.45	−0.10	0.08	−1.24	−0.12	0.04	−2.81
Colombia	−0.05	0.03	−1.49	−0.01	0.02	−0.71	−0.06	0.08	−0.75
Costa Rica	−0.12	0.04	−2.75	−0.09	0.03	−3.24	0.03	0.10	0.34
Ecuador	−0.07	0.04	−1.89	−0.03	0.02	−1.45	−0.11	0.09	−1.20
El Salvador	−0.03	0.03	−1.00	−0.09	0.04	−2.36	−0.23	0.08	−2.97
Guatemala	−0.03	0.03	−1.11	−0.03	0.02	−1.25	−0.09	0.06	−1.56
Honduras	−0.09	0.05	−1.94	−0.05	0.05	−0.90	−0.19	0.09	−2.18
Mexico	−0.08	0.03	−2.25	−0.03	0.02	−1.57	−0.37	0.19	−1.94
Nicaragua	−0.01	0.03	−0.25	−0.15	0.10	−1.59	−0.37	0.08	−4.80
Panama	−0.02	0.02	−0.84	−0.03	0.02	−1.21	0.00	0.08	−0.01
Paraguay	−0.04	0.04	−1.20	0.01	0.02	0.32	−0.11	0.07	−1.68
Peru	−0.04	0.04	−0.98	−0.08	0.05	−1.58	0.09	0.08	1.10
Uruguay	−0.12	0.05	−2.18	−0.16	0.08	−1.94	−0.05	0.11	−0.41
Venezuela	−0.02	0.04	−0.54	−0.11	0.05	−2.14	−0.15	0.11	−1.30

Source: Own elaboration.

Table 7

SPEED OF ADJUSTMENT COEFFICIENTS (INDIVIDUAL AND PANEL) ESTIMATED THROUGH THE PMG ESTIMATOR OF IM, PESARAN AND SHIN (1999) RELATIVE TO REGION'S AVERAGE

	Total sample			*First period*			*Second period*	
	$\widehat{\theta}_i$	*Std. error*	*z*	$\widehat{\theta}_i$	*Std. error*	*z*	$\widehat{\theta}_i$	*Std. error*
Argentina	−0.12	0.05	−2.30	−0.12	−2.30	−0.06	0.11	−0.54
Bolivia	−0.07	0.02	−2.96	−0.07	−2.96	−0.38	0.15	−2.57
Brazil	−0.05	0.02	−2.92	−0.05	−2.92	−0.45	0.17	−2.71
Chile	−0.01	0.03	−0.18	−0.01	−0.18	−0.12	0.03	−4.71
Colombia	−0.07	0.04	−1.73	−0.07	−1.73	−0.16	0.13	−1.24
Costa Rica	−0.30	0.07	−4.52	−0.30	−4.52	−0.04	0.09	−0.44
Ecuador	−0.08	0.05	−1.74	−0.08	−1.74	−0.21	0.15	−1.43
El Salvador	−0.03	0.03	−0.91	−0.03	−0.91	−0.20	0.06	−3.14
Guatemala	−0.05	0.04	−1.24	−0.05	−1.24	−0.32	0.12	−2.70
Honduras	−0.11	0.05	−2.37	−0.11	−2.37	−0.29	0.10	−2.99
Mexico	−0.09	0.04	−2.02	−0.09	−2.02	−0.30	0.17	−1.72
Nicaragua	−0.01	0.03	−0.26	−0.01	−0.26	−0.43	0.08	−5.45
Panama	−0.02	0.02	−0.66	−0.02	−0.66	0.10	0.08	1.23
Paraguay	−0.08	0.04	−2.06	−0.08	−2.06	−0.19	0.07	−2.71
Peru	−0.05	0.04	−1.30	−0.05	−1.30	0.08	0.08	1.05
Uruguay	−0.08	0.04	−1.90	−0.08	−1.90	−0.07	0.11	−0.66
Venezuela	0.00	0.03	−0.02	0.00	−0.02	−0.11	0.12	−0.87
United States	−0.02	0.03	−0.93	−0.02	−0.93	−0.04	0.09	−0.41

Source: Own elaboration.

Tables 6 and 7 show adjustment speed coefficients estimated through the PMG estimator, taking GDP per capita of the USA and a region's average as leading economy, respectively.

As can be seen in the tables above, most of the adjustment speed coefficients estimated for the whole period and for the subperiods considered are negative. This tends to corroborate the presence of a long-run steady-state relation between the variables analyzed, despite the fact that some individual adjustment coefficients were not significant.

Thus, through the PMG estimator we find evidence of Latin American convergence toward the USA only for the second subperiod, between 1990 and 2010. On the other hand, through the same estimators we find evidence of convergence toward a region's average only for the total sample; yet, paradoxically, we do not find evidence of convergence toward this indicator when the analysis is carried out by subperiods.

5. CONCLUSIONS

In this paper, we review the convergence hypothesis for individual Latin American countries relative to two references considered as *leading economies,* GDP per capita of the USA and a region's average. In order to prove the convergence hypothesis in Latin American countries relative to the leading economy, we employ restricted and unrestricted versions of the test for the whole period analyzed, 1951-2010, and for two subperiods: the first from 1951 to 1990 and the second from 1990 to 2010. The aim of this was to identify, for the total sample and the subperiods, whether there was a process of convergence toward the leading economy before and after the process of trade liberalization registered in most countries of the region.

With respect to the unrestricted version of the test, MW (1999) and Pesaran (2007) tests carried out with and without trend show that for the total sample and the first subperiod it is not possible to reject the unit root null hypothesis for any case in the panel considered when GDP per capita of the USA is assumed as leading economy. Meanwhile, for the second subperiod in some cases MW and Pesaran tests reject the unit root hypothesis, in this way giving some indications of stationarity in the difference of GDP per capita of each Latin American country relative to that of the USA and, therefore, of convergence between both indicators for the period of trade liberalization. In addition, MW and Pesaran tests applied to the restricted version of the test taking average GDP per capita of the region as leading economy, provide a similar result for both the total sample and for the first subperiod given that it is not possible to reject the unit root null hypothesis of this variable for any case in the panel. And for the second subperiod, both the MW test and that of Pesaran, in some cases, allow for rejecting the unit root hypothesis. These results suggest the presence of some indications of *stationarity* in the difference between GDP per capita of each Latin American country and the indicators considered as *leading economies* and, therefore, of convergence toward both indicators for the second subperiod (1990-2010).

The panel cointegration tests employed for proving cointegration between GDP per capita of Latin American countries and indicators for the *leading economy* show evidence of cointegration across such variables in both cases only for the second subperiod.

Finally, the results found through PMG, MG and DFE estimators applied to the unrestricted version of the test showed that when GDP per capita of the USA is considered as leading economy, the convergence hypothesis is only fulfilled during the second subperiod, which is in line with the results of the restricted test applied to the same indicator. Nonetheless, the estimations carried out to test β convergence taking a region's average as leading economy revealed that the PMG estimator of β had a value very close to one only for the total sample, as well as the fact that it is not possible to reject the null hypothesis that this parameter is equal to one. Estimations for this indicator therefore suggest a process of convergence toward the regional average.

However, these results are not consistent with those found with the restricted version of the test. In general, they are very consistent with those obtained in the works of Rodríguez et al. (2012), Martín-Mayoral (2010) and Barrientos (2007).

Thus, we have found conclusive evidence for the convergence of Latin American countries toward the USA with both tests, restricted and unrestricted, *only* for the second subperiod, where trade liberalization and globalization appear to have had a positive impact. It is important to point out that despite the fact that this empiric evidence provides some support to the version of absolute convergence for countries of the region toward the leading economy of the USA, for the second period of the sample we cannot say there is evidence of absolute convergence given that it is necessary to prove that intercept α_i of Equation 7, homogenous and heterogeneous, as the case may be, is equal to 0, which as far as we know is not possible with the econometric methodology employed here. We therefore confine ourselves to reporting that we found evidence of convergence toward the USA in the second period analyzed.

We also find mixed evidence of convergence toward a region's average for the total sample and for the second subperiod, given that in this case the restricted version tests suggest the presence of convergence in the second subperiod, while the PMG estimator denotes evidence of convergence only for the sample. We therefore believe more research is required in this area using different techniques –linear or non-linear– that help to explain the reasons behind such results.

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