



# ARE SOUTH AMERICAN COUNTRIES REALLY CONVERGING?: THE INFLUENCE OF THE REGION'S INTEGRATION PROJECTS

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## Abstract

Since 2000, South American economies have undertaken several regional projects to eliminate socioeconomic inequalities and improve citizens' living standards. This study evaluates the convergence in real GDP per-capita, as a suitable proxy measure, of 10 Unasur members, namely Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Peru, Uruguay, Paraguay, and Venezuela, for the period 1951--2011. By relying on cointegration techniques and applying Bernard and Durlauf's (1995) stochastic definitions of convergence and common trends, the presented evidence supports the existence of common long-run trends driving output in South America, meaning that the region is involved in a dynamic process of convergence in living standards

**Keywords:** cointegration; convergence; economic integration; South America; Unasur

**JEL Classification:** C32, O40, O54

## 1. Introduction

After a decade of economic instability and recurrent crises during the 1990s, South American countries adopted the so-called Brasilia Statement in September 2000, which aimed to improve regional integration, with a focus on peaceful coexistence, democracy, cross-border cooperation, and shared economic and social development. In the same year, the Initiative for the Integration of Regional Infrastructure in South America (IIRSA) was launched, and then eight years later, the Union of South American Nations (Unasur) was formally created as a juridical entity with an international presence.<sup>2</sup>

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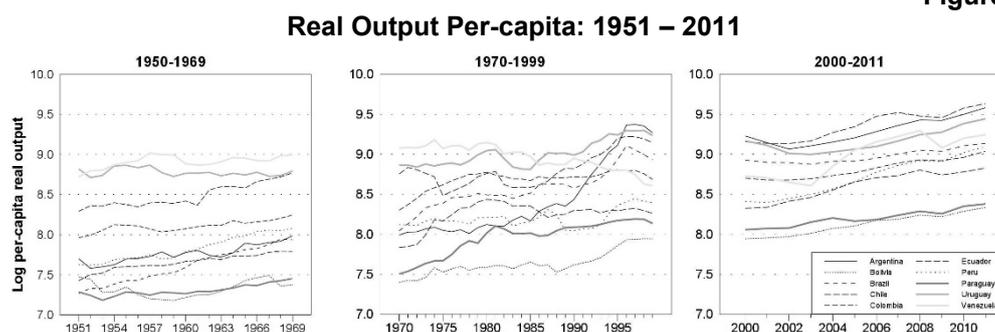
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<sup>2</sup> *The 12 members of Unasur are Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Guyana, Paraguay, Peru, Suriname, Uruguay, and Venezuela. French Guiana, one of the four overseas departments of France, is the only South American continental area not part of Unasur. The Unasur Constitutive Treaty, signed in 2008, was ratified by all signatory countries in 2011.*

## Are South American Countries Really Converging?

Although the economic impact of the relatively recently incepted Unasur integration project on regional economic growth and output convergence is hard to assess, a change is undeniably in progress. Indeed, the economies of South America have overcome the region's historically unstable growth pattern since 2000. For example, Figure 1 presents the increasing trend of both the level and the growth of real output per-capita in Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Peru, Paraguay, Uruguay, and Venezuela from 1951 to 2011.<sup>3</sup> As shown by Figure 1, real output per-capita in most countries, except for Venezuela, was smoother in the 2000s relative to previous decades. This phenomenon is even more striking considering that the 2000s were not spared economic turmoil, notably the 2007--2009 global financial crisis through which most Latin American countries passed relatively unharmed (Boonman et al., 2012). Several reasons can explain such a phenomenon, such as improvements in external balance sheets (Ocampo, 2009) and the development of domestic bond markets (Jara et al., 2009); however, as also shown by Figure 1, economic growth in South American countries not only is smoother than before but also seems to be synchronized regionally. The combination of these trends has led researchers to wonder whether the regional integration project adopted by Unasur members has contributed in some way to this change in historical pattern, a question this study aims to answer.

Figure 1



One of the main principles driving the long-term objective of Unasur is the reduction of asymmetries between members (in other words, the elimination of socioeconomic inequalities) in order to improve citizens' living standards.<sup>4</sup> In the pursuit of this objective, member nations have undertaken a series of *short-term actions*. For instance, members are carrying out 31 regional infrastructure projects relating to transport, energy, and communications. Similarly, a monetary fund and lending organization termed the "Bank of the South" was created in 2009 to finance regional development projects. In addition, since 2006, all South American citizens have been permitted to move freely within their territories, while Argentina, Bolivia, Brazil, Chile, Paraguay, and Uruguay have all approved "free residence with the right to work". All these initiatives aim to meet Unasur's driving principle of reducing the gap between members' income levels and relative living standards, of which real GDP per-capita has been shown to be an accurate measure. On this basis, we can better understand the impact of the Unasur project by analyzing the dynamics of the real

<sup>3</sup> These data are derived from the Penn World Tables 8.0 and correspond to expenditure-side real GDP at chained PPPs (in mil. 2005US\$) series normalized by population.

<sup>4</sup> See Art. 2 of the Constitutive Treaty of Unasur.

GDP per-capita series of South American countries. In particular, if the region is evolving towards the full attainment of its common goal, the individual steady states of economic growth in each Unasur country should be approaching each other over time, with convergence the ultimate endpoint (in other words, *short-run actions* are guiding the countries towards a common well-being state in which dissimilarities between citizens' living standards no longer exist).

It is possible to study regional integration in South America by using the econometric tools developed to analyze the validity of the convergence hypothesis of growth economics. Based on the predictions of the neoclassical growth model (Solow, 1956), the convergence hypothesis contends that the per-capita incomes of poorer economies will tend to grow at faster rates than those of richer economies. As a result, the per-capita income of structurally similar economies should eventually converge (Barro and Sala-i-Martin, 2004). The convergence hypothesis has attracted vast research interest (Barro and Sala-i-Martin, 1991, among others). Moreover, subsequent research has not only provided several tools to analyze the convergence hypothesis empirically ( $\beta$ - and  $\sigma$ -convergence regressions, distribution dynamics, state space models, time series models), but also refined the traditional definition of convergence, giving birth to the concepts of *absolute*, *relative*, and *club convergence* (see Durlauf *et al.*, 2005, Islam, 2003, for surveys). This study uses the developments of this rich branch of knowledge to evaluate the South American integration project. Importantly, its purpose is not to contribute to the convergence debate but rather to assess Unasur's initiative with the tools traditionally used to evaluate this hypothesis.

Among existent approaches, time series-based methods are frequently applied because of their dynamic stochastic characteristics (see Section 3). Notably, stochastic definitions of convergence and common trends in output, which can be naturally tested by using cointegration techniques, are relied on Bernard and Durlauf (1995). Contrary to classical tests ( $\beta$ - and  $\sigma$ -convergence) that only tell us whether convergence has occurred over a given period, this approach also confirms whether convergence is an ongoing process. This additional advantage is important for the embryonic South American case examined herein because convergence remains in the process of occurring.

The analysis in this study divides into two stages. First, bivariate cointegration and rolling cointegration tests are performed over annual series of the log real GDP per-capita of 10 South American countries in order to verify the existence of convergence and their common trends in output.<sup>5</sup> Second, the same data are tested in a multivariate context with subgroups of countries constructed based on both institutional aspects and the bivariate evidence obtained in the first stage (see Section 4).

Although relatively little is known about the convergence process in Latin America, a few recent studies have tackled issues similar to those examined in the present study. For example, Dobson and Ramlogan (2002a) unearth little support for the convergence hypothesis in Latin America using a panel of 19 countries over the period 1970-1998. The authors estimate cross-section regressions and apply  $\beta$ - and  $\sigma$ -convergence definitions. Dobson and Ramlogan (2002b) support this result for the period 1960-1990 based on alternative data sources. The findings of both these studies suggest a need for regional development policies in order to reduce income inequalities. Galvao and Reis-Gomes (2007) unveil some caveats of the approach by Dobson and Ramlogan (2002b) and reexamine the Latin American case for the period 1951-1999, finding evidence of convergence across the

<sup>5</sup> The countries included in this study are Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Paraguay, Peru, Uruguay, and Venezuela.

region but stronger convergence within South and Central America. However, none of these studies covers data series after 2000 and hence they do not capture the dynamics created by the South American integration initiative.<sup>6</sup> Moreover, these studies use cross-section tests, which have been shown to be associated with a weaker notion of convergence than time series tests (Bernard and Durlauf, 1996).

Essentially, this study tests whether regional integration efforts in South America have the potential to bind these continental economies together. The absence of convergence would suggest the need for further policies to reduce income inequalities, while evidence of convergence in output would be interpreted as a positive assessment of the integration project without implying that regional asymmetries in living standards no longer exist.

The remainder of the paper is organized as follows. Section 2 briefly discusses the findings of the empirical literature on the synchronization of business cycles and justifies the assertion that the output of South American countries is synchronized in the short run. As short-run synchronization does not necessarily mean long-run convergence, Section 3 introduces the long-run approach in order to assess the effectiveness of South American initiatives towards the convergence of living standards. Section 4 presents the results, which provide evidence of the existence of long-run trends driving output in South America, while Section 5 concludes, including suggestions for future research avenues.

## 2. Short-run Evidence

The study of business cycle synchronization across countries belonging to an integrated (or progressively integrated) region has become a topic of increasing interest in recent years. Both academics and policymakers have examined the implications of globalization, notably the formation of currency unions in Europe and Africa and the Asian and South American projects of economic integration, to evaluate whether economic policy coordination among countries leads to more synchronized business cycles.<sup>7</sup> Previous studies have mainly addressed groups of developed countries such as the OECD (Déés and Zorell, 2012, Kappler and Sachs, 2013, among others), G7 (Canova *et al.*, 2007, Kose *et al.*, 2003, among others), and European Monetary Union (Antonakakis and Tondl, 2014; Lee, 2013, among others) as well as countries belonging to a trade agreement or a currency union.<sup>8</sup> In the context of the current case, interest in the South American region originates from the creation of Mercosur, the continental common market (Allegret and Sand, 2009), as well as the formation of Unasur (Bonilla-Bolaños, 2014).

Business cycle co-movements have been examined *directly* by comparing the dynamic behavior of national business cycles within a group of countries and *indirectly* by focusing on the determinants of business cycle synchronization. On the one hand, studies relying on *direct approaches* either assume the existence of a common cycle and evaluate its importance for explaining country-specific movements (Canova *et al.*, 2007) or calculate

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<sup>6</sup> This fact is also true for other works that have explored convergence issues in Latin America (Engle and Issler, 1993, Holmes, 2005).

<sup>7</sup> According to the theory of optimum currency areas, the synchronization of national business cycles is a necessary condition for stabilizing monetary policy within a currency union, which explains the interest of groups involved in – or projecting to form – a monetary union.

<sup>8</sup> Asian and African business cycle co-movements have been widely analyzed in the context of their monetary union projects (i.e., Gong and Kim, 2013, Nguyen *et al.*, 2014).

concordance indexes and correlations of business cycle timings across countries without imposing a common cycle (Thomakos and Papailias, 2014).

On the other hand, indirect approaches aim to understand the dynamics of the determinants of business cycle co-movements, with positive trends in such determinants presumed to boost synchronization. However, evidence on how the evaluated channels (namely, bilateral trade, industrial structure, financial integration, distance between two countries, degree of development, similarity of exports and imports, foreign direct investment, cultural differences) influence business cycle co-movements is mixed. Despite this lack of consensus, the role of symmetric shocks as a synchronization driver has been widely highlighted by authors as a determinant of the strength of cycle co-movement (Babetskii, 2005, Bordo and Helbling, 2011, Jackman and Moore, 2008).<sup>9</sup> Because the similarity of economic shocks has proven to enhance Latin American business cycle synchronization (Jackman and Moore, 2008), a number of studies have evaluated South American short-run co-movements by measuring the responses of macro variables to several shocks, notably external shocks (for instance, monetary, financial, commercial), and the empirical evidence suggests that important regional co-movements do exist (Allegret and Sand, 2009, Bonilla-Bolaños, 2014, Canova, 2005, Mackowiak, 2007, among others). Similar responses to such shocks are assumed to cause business cycle synchronization (through indirect approaches). Indeed, Aiolfi *et al.* (2011) discuss the considerable commonality of cyclical fluctuations across Argentina, Brazil, and Chile when analyzing their business cycles by using a common factor approach (that is, a direct approach).

**Table 1**

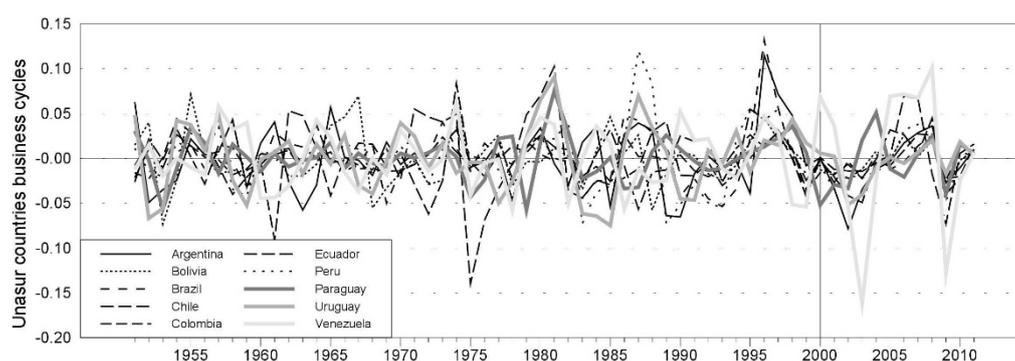
**Business Cycle Pairwise Correlations**

	All	1951-1960	1961-1970	1971-1980	1981-1990	1991-2000	2001-2010
Average	0.268	0.207	0.062	0.320	0.088	0.421	0.609

*Notes: This table reports the decade-by-decade average of the business cycle pairwise correlations for Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Peru, Paraguay, Uruguay, and Venezuela. The cyclical component of real output is recovered by HP-filtering the annual logged real output per-capita series. Data are derived from the Penn World Tables 8.1 and cover the period 1951 to 2011.*

**Figure 2**

**Business Cycles: 1951-2011. HP-filtered. Dampening Value  $\lambda$  Set to 6.25**



<sup>9</sup> Optimum currency area theory asserts that countries facing symmetric shocks are better candidates to form a monetary union.

In fact, this evidence of short-run synchronization seems to be confirmed by the positive evolution of business cycle correlation across countries in the region. Figure 2 illustrates the business cycles of Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Peru, Paraguay, Uruguay, and Venezuela from 1951 to 2011, highlighting that the cyclical component of output across countries was highly synchronized during the 2000s relative to past decades. The pairwise correlations in Table 1 provide a quantitative measure of this fact. The average business cycle correlation across countries increased between 2000 and 2010 (the highest decade-by-decade correlation coefficient corresponds to the 2000-2011 period, 0.609, which is far from negligible). This decade-by-decade comparison suggests that countries are evolving towards a convergent long-run path, especially given that the average business cycle correlation of the whole period (1951-2011) is only 0.268.

It must be noted, however, that business cycle synchronization does not necessarily imply that economic convergence is occurring (that is, synchronization may exist but the cycles could have distinct amplitudes because of non-convergence). The term convergence is associated with the catch-up effect among nations' growth rates (convergence hypothesis), while synchronization means that similar movements in countries' growth rates exist over time (Crowley and Schultz, 2010). Whether such (short-run) synchronization translates into (long-run) convergence is the issue on which the next section sheds some light.

### **3. A long-run Evidence**

Numerous debates in growth and development economics center on whether there is a tendency for poorer countries to grow more rapidly than richer countries and thereby towards a convergence in living standards (Abramovitz, 1986, Barro and Sala-i-Martin, 1991, 1992, Baumol, 1986), spawning a vast body of research typically referred to as the "convergence literature".<sup>10</sup>

The convergence literature aims to understand the sources of persistent regional differences in per-capita GDP and growth rates by testing whether income per-capita in a given set of economies converges to the same long-run path (absolute convergence). A wide set of econometric tools are used to this end. Classical tests of convergence measure either that the coefficient attached to the initial level of income per-capita in a cross-section growth regression is negative ( $\beta$ -convergence) (Barro and Sala-i-Martin, 1991, 1997) or that some measure of income dispersion is decreasing over time ( $\sigma$ -convergence) (Cannon and Duck, 2000, Friedman, 1992). Subsequent empirical research has described the main drawbacks of such static methods (Durlauf *et al.*, 2005) and propose several alternative approaches for analyzing this issue, such as distribution dynamics (Quah, 1996), state space models (Bulli, 2001), time series approaches (Bernard and Durlauf, 1995, 1996), panel data models (Evans, 1998, Islam, 1995), event study approaches (Pritchett, 2000), and nonlinear tests (Enders and Lee, 2012).<sup>11</sup>

Time series approaches are suitable for analyzing the South American case because they consider both stochastic and dynamic characteristics. Indeed, the very nature of an integration process is dynamic and uncertain. The aim of eliminating asymmetries in living standards among the region's citizens is a continuing (dynamic) long-run (uncertain/stochastic) process. Bernard and Durlauf (1995) provide a framework within

<sup>10</sup> See Barro and Sala-i-Martin (2004), Durlauf *et al.* (2005), Islam (2003), Temple (1999) for reviews of the convergence literature.

<sup>11</sup> Only the pioneering studies are mentioned here to save space.

which to analyze convergence in such an environment. The authors develop stochastic definitions of convergence and common trends that can be easily tested with time series cointegration techniques. As noted in the Introduction, the approach used herein is especially suitable for examining the impact of Unasur because it can tell us whether convergence is an ongoing process, contrary to classical tests  $\beta$ - and  $\sigma$ -convergence) that only express whether convergence has occurred over a given period.

### 3.1. The Theory

Defining convergence and long-run fluctuations in output stochastically requires the individual series under analysis to be non-stationary processes. Let  $Y_{i,t}$  be the  $n \times 1$  vector containing the log real GDP per-capita output ( $y_{i,t}$ ) series of the  $n$  Unasur members and model  $Y_{i,t}$  as satisfying

$$a(L)Y_{i,t} = \mu_{i,t} + \varepsilon_{i,t} \tag{1}$$

where  $a(L)$  has a unit root and  $\varepsilon_{i,t}$  is a white noise process meaning that the definitions provided by Bernard and Durlauf (1995) can be applied to the South American case examined herein.

According to Bernard and Durlauf (1995), for countries  $i$  and  $j$  (or countries  $p=1, \dots, n$ ) to converge, the long-run forecast of their output differences must tend to zero as the forecast horizon tends to infinity (Definitions A.1. and A.2. in Table 2). Thus, if the living standards of two (or more) Unasur countries converge, the output gap between them will tend to disappear in the long-run.<sup>12</sup> Although this definition of convergence seems to be the ideal result of an integration process, Unasur members are unlikely to satisfy such a strict characterization. The embryonic state of the South American regional integration project leads us to expect to reject the null hypothesis of convergence in output. Even if South American countries do not satisfy the A.1. and A.2. Definitions, however, they may still be evolving towards the common long-run objective of a convergence in living standards, meaning their individual output paths must respond to the same long-run driving process. In other words, South American countries must have common stochastic trends in output (Definitions B.1. and B.2. in Table 2).

Table 2 presents the definitions of convergence and common trends in output proposed by Bernard and Durlauf (1995) as well as its empirical testable analog.<sup>13</sup> These tests will be applied to the South American output series in order to uncover some evidence on the current integration status of the region.

**Table 2**  
**Bernard and Durlauf's (1995) Definitions of Convergence and Common Trends in Output**

Definition	Cointegration Equivalent
A.1. Convergence in output Countries $i$ and $j$ converge if the long-term forecasts of output for both countries are equal at a fixed time $t$ : $\lim_{k \rightarrow \infty} E(y_{i,t+k} - y_{j,t+k}   I_t) = 0$	Countries $i$ and $j$ converge if their output series are cointegrated with the cointegrating vector $[1, -1]$

<sup>12</sup> Henceforth, every reference to output is to log real GDP per-capita, which is assumed to be a comparable measure of living standards across countries.

<sup>13</sup> Each definition in Table 2 has a natural testable analog from the unit root/cointegration literature. See Bernard and Durlauf (1995) for more details.

Definition	Cointegration Equivalent
<p>A.2. Convergence in multivariate output                      Countries <math>p=1, \dots, n</math> converge if the long-term forecasts of output for all countries are equal at a fixed time <math>t</math>:</p> $\lim_{k \rightarrow \infty} E(y_{1,t+k} - y_{p,t+k}   I_t) = 0 \quad \forall p \neq 1$	<p>In order for the individual output series of all <math>p</math> countries to converge, there must exist <math>p-1</math> cointegrating relations of the form <math>[1, -1]</math>.<sup>14</sup></p>
<p>B.1. Common trends in output                      Countries <math>i</math> and <math>j</math> contain a common trend if the long-term forecasts of output are proportional at a fixed time <math>t</math>:</p> $\lim_{k \rightarrow \infty} E(y_{i,t+k} - \alpha y_{j,t+k}   I_t) = 0$	<p>Countries <math>i</math> and <math>j</math> have a common trend if their output series are cointegrated with the cointegrating vector <math>[1, \infty]</math></p>
<p>B.2. Common trends in multivariate output                      Countries <math>p=1, \dots, n</math> contain a single common trend if the long-term forecasts of output are proportional at a fixed time <math>t</math>, let <math>\hat{y}_t = [y_{2,t}, y_{3,t}, \dots, y_{p,t}]</math>:</p> $\lim_{k \rightarrow \infty} E(y_{1,t+k} - \alpha_p \hat{y}_{t+k}   I_t) = 0$	<p>All <math>p</math> countries share a single common stochastic trend if there exists just one cointegrating relation between them.</p>

### 3.2. Data and Econometric Methodology

In the present study, the annual series of log real GDP per-capita in 2005 PPP-adjusted dollars of Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Paraguay, Peru, Uruguay, and Venezuela are used.<sup>15</sup> These data are derived from the Penn World Tables 8.0 and cover the period 1951 to 2011.<sup>16</sup> The tests of convergence and common trends follow the procedures developed by Engle and Granger (1987) and Johansen (1991). Uncovering the presence of unit roots in individual output series relies on the traditional augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests.

The analysis is conducted in two stages. First, bivariate tests of convergence and common trends for all 45 possible country pairings for the 10 included Unasur countries are performed. Second, similar tests of convergence and common trends are carried out in a multivariate environment. In both stages, the null hypothesis of no convergence is tested; if that null cannot be rejected, the number of common trends in output is assessed.

Let  $y_{i,t}$  denote the output level of the country and  $Y_{i,t}$  the  $n \times 1$  vector of the individual output levels.  $Dy_{i,t}$  is the deviation in output in country  $i$  from that of the benchmark country,  $Dy_{i,t} = y_{1,t} - y_{i,t}$ . The operator  $\Delta$  indicates the first difference of the series.

If all the individual output series are integrated of the same order, particularly of order one  $I(1)$  (as we are working with real GDP series), vector  $Y_t$  can be written in the Wold representation of the form

$$\Delta Y_t = \mu + C(L)\varepsilon_t \tag{2}$$

Engle and Granger (1987) demonstrate that if the  $p$  output series are cointegrated in levels with  $r$  cointegrating vectors, then  $C(1)$  is of rank  $p-r$  and there is a vector ARMA representation for (2). The residuals-based methodology for testing cointegration developed by Engle and Granger (1987) estimates the following regression

<sup>14</sup> Alternatively, the output deviations from the benchmark country ( $y_{1,t+k} - y_{p,t+k}$ ) must be a zero-mean stationary process

<sup>15</sup> Surinam and Guyana are not included owing to data availability. The sample thus represents 10 of the 12 Unasur members.

<sup>16</sup> The Penn World Tables 8.0 provide data on real GDP in 2005 PPP-adjusted dollars and population; the rest is a matter of data transformations.

$$y_{1,t} = \alpha_0 + \alpha_1 y_{2,t} + \alpha_2 y_{3,t} + \dots + \alpha_{n-1} y_{n,t} + \varepsilon_t^{17} \quad (3)$$

and uses the estimated residuals  $\hat{\varepsilon}_t$  to construct the ADF statistics for  $\theta$  from a second equation

$$\Delta \varepsilon_t = -\theta \varepsilon_{t-1} + B(L)\Delta \varepsilon_t + \zeta_t^{18}$$

If a cointegration relation exists between the series, the null that  $\theta=0$  must be rejected. However, a major drawback of this test is its relatively low power against other alternatives, especially in multivariate contexts.<sup>19</sup> Because of this shortcoming, the Johansen (1991) technique is also applied. Johansen's (1991) test estimates the rank of the cointegrating matrix  $\Pi$  from a finite-vector autoregressive representation of the output vector of the form

$$\Delta Y_t = \Gamma(L) \Delta Y_t + \Pi Y_{t-1} + \Phi D_t + \varepsilon_t \quad (4)$$

where:

$$\Gamma_i = -(A_{i+1} + \dots - A_k), \quad (i = 1, \dots, k - 1)$$

$$\Pi = -(I - A_1 - \dots - A_k)$$

$\Gamma(L)$  captures the short-run dynamics, while the long-run relationships of the individual series are captured by  $\Pi$ .  $D_t$  contains the deterministic terms. As cointegration refers to long-run relationships, Johansen's (1991) test is based on the rank of  $\Pi$ . If  $\Pi$  has a reduced rank, it can be written as

$$\Pi = \alpha \beta' \quad (5)$$

with  $\alpha$  and  $\beta$  representing the  $p \times r$  matrices of rank  $r \leq p$ .  $\beta$  is the matrix of the cointegrating vectors. If the rank of  $\Pi$  is  $0 < r < p$ , there are  $r$  cointegrating vectors for the individual series in  $Y_t$ , and hence the group of output time series is being driven by  $p-r$  common shocks.<sup>20</sup> Although, for any normalization chosen,  $\beta$  is not uniquely determined (indeed, a different  $\alpha$  satisfying relation (5) will produce a different  $\beta$ ), the rank of  $\Pi$  is still related to the number of cointegrating relations. Therefore, for our purposes, the test is not sensitive to the selected normalization.

Johansen's (1988, 1991) test explains the relation between the rank of the MLE-estimated matrix  $\Pi$  and its characteristic roots and proposes two statistics for testing the number of cointegrating relationships: the likelihood ratio (LR) trace and maximum eigenvalue statistics. These tests are based on the estimated eigenvalues  $\lambda_1 > \lambda_2 > \dots > \lambda_p$  of the matrix  $\Pi$ . The statistics are

$$LR_{trace}(r_0) = -T \sum_{i=r_0+1}^n \ln(1 - \hat{\lambda}_i) ; \quad LR_{max}(r_0) = -\ln(1 - \hat{\lambda}_{r_0+1}) \quad (6)$$

If estimated  $\Pi$  is of full rank,  $p$ , no characteristic root will be equal to zero. If instead  $\Pi$ 's rank is  $0 < r < p$ , then it will have  $p-r$  zero characteristic roots. The null hypothesis of the trace statistic is that the rank of the cointegrating matrix is  $r$  and the alternative hypothesis is that

<sup>17</sup> This is a cointegrating regression because it represents the long-run relationship between the variables.

<sup>18</sup> This specification allows for non-white noise  $\varepsilon_t$  residuals.

<sup>19</sup> When  $n > 2$ , there could exist more than one cointegrating relation, possibility not accounted for by using Engle and Granger's (1987) method.

<sup>20</sup> If the rank of  $\Pi$  is equal to  $p$ , then  $Y_t$  is a stationary process. If the rank of  $\Pi$  is zero, then there are  $p$  stochastic trends and long-run output levels are not related across countries.

the rank is  $p$ . For the maximum eigenvalue statistic, the null and alternative hypotheses are that the rank is  $r$  and  $r + 1$ , respectively.

### **Bivariable Tests**

For the pairwise analysis, the cointegrating regression (3) is estimated for each of the 45 pairs of countries in its bivariate version of the form

$$y_{i,t} = c_{ij} + \alpha_{ij}y_{j,t} + \varepsilon_{ij,t} \quad (7)$$

where:  $y_{i,t}$  and  $y_{j,t}$  are  $I(1)$ . ADF statistics are computed next by using the estimated residuals  $\hat{\varepsilon}_{ij,t}$ . The stationarity of  $\hat{\varepsilon}_{ij,t}$  is taken as evidence of a common long-run driving process for output in countries  $i$  and  $j$  (Definition B.1.).

To test the convergence hypothesis, the residuals are computed directly as  $\varepsilon_{ij,t} = y_{i,t} - y_{j,t}$ . The stationarity of  $y_{i,t} - y_{j,t}$  implies that the cointegrating vector is  $[1, -1]$ . The output of countries  $i$  and  $j$  will then be proven to satisfy the convergence hypothesis (Definition A.1.), namely the standards of living in both countries will be similar.<sup>21</sup>

### **Multivariate Test**

The multivariate convergence and common trends for the 10 Unasur countries are tested by using Johansen's (1991) procedure as described previously. The asymptotic null distribution of the LR trace and maximum likelihood statistics (6) of the Johansen test is not chi-square but instead a multivariate version of the Dickey--Fuller unit root distribution, which depends on the dimension  $p-r$  and specification of the deterministic terms  $\Phi D_t$  in the estimated system (4). A correct specification is therefore crucial for the results. Following Johansen (1995), the deterministic terms  $\Phi D_t$  are restricted to the form

$$\Phi D_t = \mu_t = \mu_0 + \mu_{1,t}$$

If the deterministic terms are unrestricted, then the time series in  $Y_t$  (4) may display quadratic trends and there may be a linear trend term in the cointegrating relationships. Restricted versions of the trend parameters  $\mu_0$  and  $\mu_1$  limit the trending nature of the series in  $Y_t$ . Johansen (1995) classifies the trend behavior of  $Y_t$  into five cases: (i)  $\mu_t = \mu_0$  (no constant), (ii)  $\mu_t = \mu_0 = \alpha \rho_0$  (restricted constant), (iii)  $\mu_t = \mu_0$  (unrestricted constant), (iv)  $\mu_t = \mu_0 = \alpha \rho_1 t$  (restricted trend), and (v)  $\mu_t = \mu_0 + \mu_{1,t}$  (unrestricted constant and trend). The critical values for the LR trace and maximum likelihood statistics' distribution are tabulated in Osterwald-Lenum (1992) and MacKinnon et al. (1999) for these five trend cases.

The levels and first differences of the output series for the 10 Unasur countries are illustrated in Figure 3. Because the  $I(1)$  output series are not trending, Johansen LR tests are computed assuming the restricted constant case (ii). Then, the estimated version of (4) is

$$\Delta Y_t = \Gamma(L)\Delta Y_t + \alpha(\beta'Y_{t-1} + \rho_0) + \varepsilon_t \quad (8)$$

<sup>21</sup> Bernard and Durlauf's (1995) definitions of convergence (Definitions A.1. and A.2. in Table 2) imply that if the output series are trend-stationary, the time trends must be the same between countries  $i$  and  $j$ . This option is accounted for by evaluating convergence as the absence of unit roots in  $y_{i,t} - y_{j,t}$ .

and the series in  $Y_t$  are  $I(1)$  without drift, and the cointegrating relations  $\beta' Y_{t-1}$  have non-zero means  $\rho_0$ .<sup>22</sup> Multivariate convergence (Definition A.2.) is tested by using Engle and Granger's (1987) technique. If all  $Dy_{i,t} = y_{1,t} - y_{i,t}$  are stationary processes, Unasur will be shown to be a convergent region. For detecting common stochastic trends within Unasur, Johansen's (1991) methodology is employed (Definition B.2.).

## 4. Results

First, the presence of stochastic trends in each of the 10 output series is tested. Figure 3 displays the level and growth of the output series and Table 3 reports the ADF and PP statistics. A graphical inspection of the individual output series suggests that they are  $I(1)$ . Indeed, the null hypothesis of a unit root in output cannot be rejected for any of the 10 output series in levels but it is rejected for the corresponding first differences. The 10 individual output series are thus  $I(1)$  processes.

We use two stages to test for convergence and common trends in output. First, as preliminary evidence, pairwise tests are performed for all 45 possible country pairings. Second, these pairwise findings are used to divide South America into subgroups. The existence of convergence and common trends within these subgroups as well as within the whole group of 10 countries is tested next by using multivariate methods.

Table 3

Unit Root Test. Log Real Per-capita Output

	ADF		PP	
	Level ( $Y_t$ )	1 <sup>st</sup> differences ( $\Delta Y_t$ )	Level ( $Y_t$ )	1 <sup>st</sup> differences ( $\Delta Y_t$ )
Argentina	-1.69971	-5.67563**	-1.89575	-7.69748**
Bolivia	-2.83084	-7.49858**	-2.90850	-5.33648**
Brazil	-1.91260	-5.20395**	-1.57064	-6.57933**
Chile	-1.30470	-6.40881**	-1.54359	-6.57933**
Colombia	-2.21851	-4.14465**	-1.39154	-4.10558*
Ecuador	-2.48565	-5.96650**	-1.53177	-6.10247**
Peru	-1.05222	-5.61371**	-0.59167	-5.78493**
Paraguay	-1.57795	-6.19008**	-1.75883	-6.35514**
Uruguay	-2.85538	-5.44327**	-2.38312	-5.63710**
Venezuela	-1.63915	-6.63171**	-1.83934	-6.80935**
Mercosur	-2.82224	-5.06776**	-2.50909	-5.23671**
CAN	-1.41252	-5.14968**	-1.03993	-5.24189**

Notes: The lag lengths of the ADF and PP statistics are chosen by the Bayesian Information Criterion (BIC). \* and \*\* denote significance at the 5 percent and 1 percent levels, respectively.

### 4.1. Pairwise Evidence

Tables 4 and 5 present the results on the pairwise convergence and the existence of common trends in output, respectively. The null of no convergence is initially tested for all pairs. If that null cannot be rejected, the presence of common trends in output is then tested. As expected, owing to the infancy of the South American integration project, no evidence of convergence is found (Table 4). In addition, none of the pairwise output gaps  $y_{i,t} - y_{j,t}$  seems

<sup>22</sup> This choice is justified for the graphical inspection of the  $I(1)$  series and pairwise results of cointegration. As a robustness check, all five options were estimated and compared by using the Bayesian information criterion (BIC.) Accordingly, option (ii) was retained.

to be a stationary process; in other words, the differences in pairwise living standards within Unasur are permanent.<sup>23</sup> However, this result cannot be interpreted as a negative assessment of the evolution towards the achievement of regional integration. Therefore, the presence of a common stochastic trend is tested next (cointegration test).

**Figure 3**

**Log Per-capita Output of the 10 Unasur Countries. Level and Growth Series**

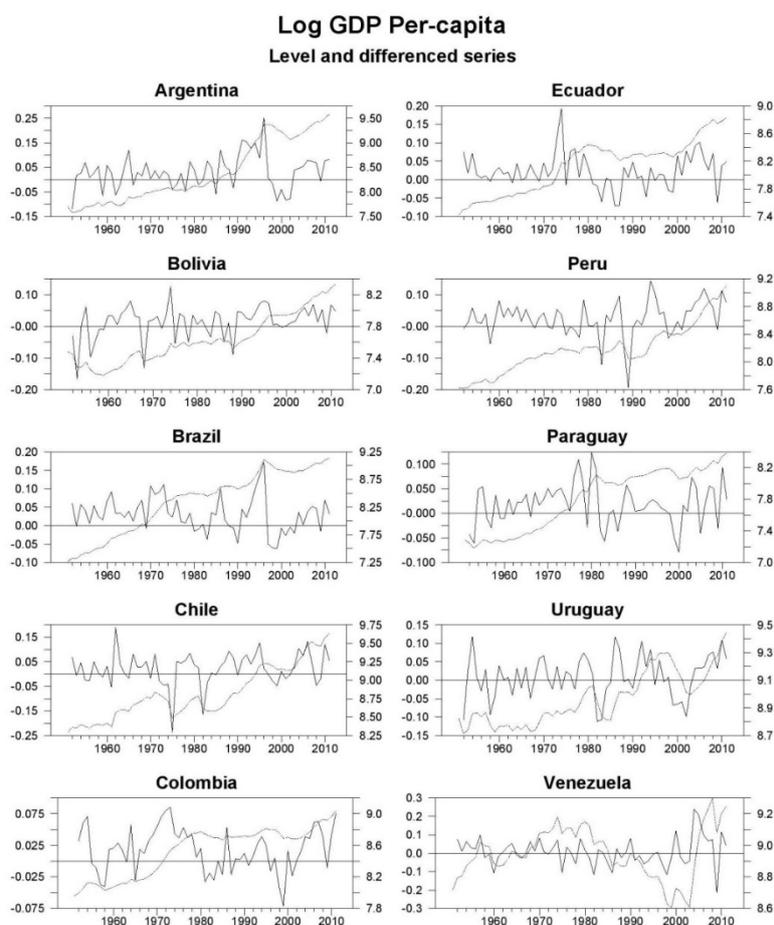


Table 5 displays the ADF statistics for testing the null of no cointegration. The null hypothesis is rejected for 17 of the 45 pairs of countries. The output of those 17 partner nations seems to be driven by a common process, supporting the belief that output growth across some pairs of South American countries shares common elements.

<sup>23</sup> This result supports historical evidence for some Latin American countries. Dobson and Ramlogan (2010) find no evidence on  $\sigma$ -convergence between a set of 19 Latin American countries (including the 10 under study herein).

Such common trends might be driven by the fact that several of the countries under analysis belong to more than one regional integration bloc.<sup>24</sup> Figure 4 presents the increasing prevalence of integration agreements among South American countries.

**Table 4**  
**Pairwise Convergence Tests for the 10 Unasur Countries: 1951 – 2011**

	AR	BO	BR	CH	CO	EC	PE	PA	UR
AR	–								
BO	-1.607	–							
BR	-1.409	-1.800	–						
CH	-2.649	-3.460	-0.661	–					
CO	-1.586	-2.217	-1.360	-0.960	–				
EC	-1.562	-1.670	-2.004	-1.789	-1.809	–			
PE	-1.521	-3.005	0.712	-2.013	-0.802	-1.911	–		
PA	-1.277	-1.075	-2.625	-0.837	-3.300	-2.106	-0.463	–	
UR	-1.830	-2.552	-1.015	-1.968	-1.510	-2.018	-2.611	-1.220	–
VE	-2.061	-3.201	-1.608	-1.832	-1.531	-2.414	-3.245	-1.726	-2.144

Notes: This table reports the ADF statistics for testing the null that  $\epsilon_{ij,t} = y_{i,t} - y_{j,t}$  is not a stationary process. The estimated equations, whose lag structure is chosen according to the BIC, are:

$$\Delta \epsilon_{ij,t} = -\theta_{ij} \epsilon_{ij,t} + B(L)\Delta \epsilon_{ij,t} + \zeta_{ij,t}$$

**Table 5**  
**Pairwise Cointegration Tests for the 10 Unasur Countries: 1951 – 2011**

	AR	BO	BR	CH	CO	EC	PE	PA	UR
AR	–								
BO	-1.607	–							
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EC	-1.562	-1.670	-2.004	-1.789	-1.809	–			
PE	-1.521	-3.005	0.712	-2.013	-0.802	-1.911	–		
PA	-1.277	-1.075	-2.625	-0.837	-3.300	-2.106	-0.463	–	
UR	-1.830	-2.552	-1.015	-1.968	-1.510	-2.018	-2.611	-1.220	–
VE	-2.061	-3.201	-1.608	-1.832	-1.531	-2.414	-3.245	-1.726	-2.144

Notes: This table reports the ADF statistics for testing the null that  $\epsilon_{ij,t}$  is not a stationary process. \* and \*\* denote significance at the 5 percent and 1 percent levels, respectively. The estimated equations are (lag structure for  $B(L)$  selected according to the BIC as before):  $y_{i,t} = c_{ij} + \alpha_{ij} y_{j,t} + \epsilon_{ij,t}$   $\Delta \epsilon_{ij,t} = -\theta_{ij} \epsilon_{ij,t} + B(L)\Delta \epsilon_{ij,t} + \zeta_{ij,t}$

By 2000, Mercosur (Argentina, Brazil, Paraguay, and Uruguay) and the Andean Community of Nations (CAN; Bolivia, Colombia, Ecuador, Peru, and Venezuela) were the main integration projects in the region.<sup>25</sup> At the time of its creation, Unasur joined Mercosur, CAN,

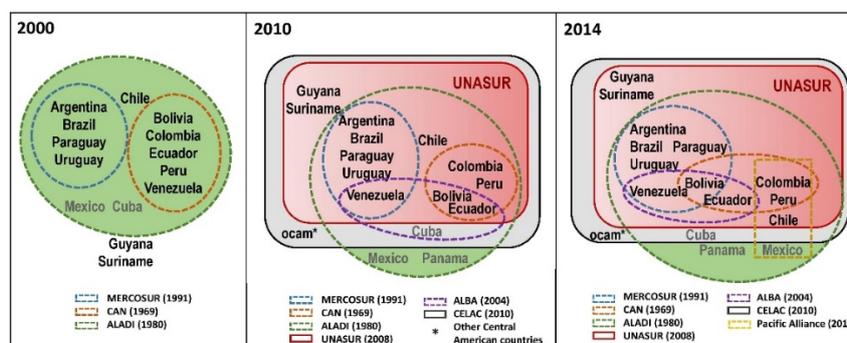
<sup>24</sup> According to Albertoni (2012), Latin America is experiencing a hyperinflation of integration projects. Indeed, he asserts that a number of countries in the region belong to three or more different blocs.

<sup>25</sup> The Latin American Integration Association (ALADI, Spanish acronym), which by 2000 included all Mercosur and CAN members as well as Chile, Mexico, and Cuba, is not considered in the analysis herein for two reasons. First, it includes some Central American countries, which are outside the scope of this study. Second, it is not considered to be a main integration project in the region according to the Faculty of Social Sciences, FLACSO (IV Report of the FLACSO's General Secretary, 2009).

Chile, Suriname, and Guyana in integrating the entire South American continent. However, conflicts drove the creation of more blocs over time. For instance, the Pacific Alliance (Colombia, Chile, Peru, and Mexico) emerged in 2011 to meet the objectives of ALBA (the Bolivarian Alliance for the Peoples of Our America, comprising Bolivia, Cuba, Ecuador, and Venezuela). ALBA was formed in 2004 in opposition to the US proposal to create a Free Trade Area of the Americas (ALCA) in order to reinforce the economic dependence of Latin America on the United States. Because the ALCA project was unsuccessful, pro-United States nations such as Colombia, Chile, and Peru signed bilateral trade agreements. These countries together with Mexico later formed the Pacific Alliance, which with ALBA confronted the South American nations in Unasur.<sup>26</sup> On the contrary, the Community of Latin American and Caribbean States (CELAC) created in 2010 has joined with South and Central American countries to extend Unasur's goal of integration.

Figure 4

Regional Integration Blocs in South America



Considering that most of the analyzed economies belong to more than one bloc, as displayed in Figure 4, and that not all these blocs share similar objectives (compare ALCA with the Pacific Alliance), the integration dynamics generated by Unasur may be offset by the differing ideologies of the other groups. Moreover, CAN is currently involved in a dissolution process and Mercosur is assessing the remaining Unasur members as part of the project to form a South American common market.<sup>27</sup> Amid the tangle of Latin American integration projects, Unasur acts as a conciliator group (Sanahuja, 2012). The aforementioned historical relationships must thus be borne in mind when interpreting the econometric evidence.

The analysis presented herein does not include Venezuela as either a Mercosur member or a CAN member for two reasons. First, Venezuela left CAN to join Mercosur in 2006 because of a disagreement over Colombia and Peru's relationships with the United States.<sup>28</sup> Second, Venezuela is the only country not classified as a founding member of either Mercosur or CAN.

Evidence of cointegration is found for four of six possible country pairings for the four long-term Mercosur members. For CAN, only three of six possible country pairings seem to be

<sup>26</sup> Briceño-Ruiz (2014) argues that Latin American integration is developing along three axes: an open integration axis represented by the Pacific Alliance, a revisionist axis symbolized by Mercosur, and an anti-systemic axis represented by ALBA.

<sup>27</sup> Venezuela has been a Mercosur member since 2006, Bolivia since 2012, and Ecuador has started the process of accession.

<sup>28</sup> Hugo Chavez, Venezuela's president at that time, was the architect of ALBA.

cointegrated. Surprisingly, Colombia's output has common stochastic trends with none of the other CAN members (see Table 5). On the contrary, Uruguay's output shares stochastic patterns with all its Mercosur partners. According to this results, aside from Colombia, the output of all other CAN members seems to be pairwise-cointegrated. By contrast, the output of Argentina and Brazil, the largest economies of Mercosur, do not share stochastic trends. This finding suggests that neither CAN nor Mercosur has succeeded in bridging the gap in the living standards of their members. In order to support these results, the results of the multivariate tests performed are presented in Section 4.2.

An interesting result is the lack of a common stochastic trend between Venezuela and the other South American countries. As illustrated in Figure 3, Venezuela's output trend differs significantly from that of the other analyzed countries, reflecting, among other factors, its conflicting relationships with some Unasur members. Contrary to Venezuela, Uruguay shares the greatest number of common stochastic trends (Uruguay's output has common driving processes with six of the nine other countries). Hence, Uruguay is chosen as the benchmark country when testing multivariate convergence (see the results in Section 4.2).

Accordingly, the following six separate groups of South American countries are selected to test the existence of multivariate common trends: a) all 10 countries taken together, b) the 10 countries excluding Venezuela, c) the 10 countries excluding Venezuela and Colombia, d) the four founding Mercosur members, e) the four founding CAN members, and f) Mercosur and CAN members plus Chile and Venezuela.<sup>29</sup> Multivariate convergence is only tested for the whole group of 10 because no pairs of countries passed the preliminary tests of convergence (see Table 4).

Mercosur and CAN are analyzed separately as opposed to other existing blocs in Figure 4 for two reasons. First, because the data sample considered in the study runs to 2011, the sample is too short to capture the dynamics caused by the disagreements between conflicting subgroups, especially as the Pacific Alliance only formed in 2011. Second, Mercosur and CAN are the only blocs formed exclusively by subsamples of Unasur members.

#### 4.2. Multivariable Evidence

Convergence in multivariate output, as determined by Definition A.2. in Table 2, requires the existence of  $p-1$  cointegrating relations of the form  $[1,-1]$ . In other words, the output deviations from the benchmark country ( $Dy_{i,t} = y_{1,t} - y_{i,t}$ ) must be a zero-mean stationary process. Accordingly, output deviations are constructed by using Uruguay as the benchmark country because, as shown by the pairwise findings, it shares the greatest number of common stochastic trends with the other analyzed Unasur members.<sup>30</sup> Because the previous bivariate test did not prove the existence of pairwise convergence, the broad null of no multivariate convergence is not expected to be rejected. Such an expectation is confirmed by the ADF and PP statistics presented in Table 6.<sup>31</sup>

<sup>29</sup> The output series of Mercosur and CAN are computed as the aggregation of their members' output.

<sup>30</sup> These results hold for any other choice of benchmark country.

<sup>31</sup> Several authors have tested the convergence hypothesis for European countries, concluding that their output does not converge (Bernard and Durlauf, 1995, Martin, 2001). Since the integration project in Europe is further advanced than that in South America, the non-rejection of the null of no convergence should not be taken as a negative evaluation of the latter project.

Table 6

Multivariate Convergence. Ten Unasur Countries

	Dy <sub>i,t</sub>	
	ADF	PP
Argentina	-1.82929	-1.95598
Bolivia	-2.55371	-2.74473
Brazil	-1.01526	-1.29108
Chile	-1.96794	-2.13717
Colombia	-1.51047	-1.67425
Ecuador	-2.01791	-2.02290
Peru	-2.61093	-1.43044
Paraguay	-1.22003	-1.42238
Venezuela	-2.14386	-2.39288

Notes: The lag length of the ADF and PP statistics is chosen by using the BIC.  $Dy_{i,t} = y_{ur,t} - y_{i,t}$  denotes output deviations. Uruguay as the benchmark country.

The presence of multivariate common trends is tested next by using Johansen's methods. The results from the Johansen trace and maximum eigenvalue statistics are presented in Table 7 for each of the six subsets of countries defined previously. The lag structure was chosen by using the BIC, with a lag length of one describing the dynamics of the system.

Table 7

Multivariate Tests for Cointegration (VAR Lag Length = 1)

Trends	All			Trends	Excluding Venezuela			Trends	Excluding VE and CO		
p-r	M.Eig.	Trace	P-Val	p-r	M.Eig.	Trace	P-Val	p-r	M.Eig.	Trace	P-Val
>9	78.7	313.62	0.000	>8	75.2	252.67	0.000	>7	58.8	185.94	0.004
>8	62.2	222.47	0.008	>7	51.9	170.42	0.044	>6	49.0	133.68	0.056
>7	44.1	165.03	0.084	>6	42.1	127.30	0.125	>5	42.0	93.97	0.189
>6	42.0	130.69	0.083	>5	40.2	95.03	0.167	>4	34.9	61.80	0.408
>5	40.1	98.54	0.106	>4	30.9	64.67	0.302	>3	27.7	36.50	0.653
>4	31.0	68.27	0.193	>3	28.1	42.84	0.341	>2	12.0	17.35	0.866
>3	27.1	46.33	0.206	>2	19.9	23.39	0.507	>1	8.3	9.83	0.661
>2	23.6	27.68	0.259	>1	8.8	10.32	0.615	>0	7.6	4.69	0.330
>1	10.4	11.78	0.477	>0	7.9	4.88	0.307				
>0	8.6	5.32	0.259								

Trends	MER+CAN+Ch+Ve			Trends	Mercosur			Trends	CAN		
p-r	M.Eig.	Trace	P-Val	p-r	M.Eig.	Trace	P-Val	p-r	M.Eig.	Trace	P-Val
> 3	48.2	64.76	0.004	>3	42.7	67.52	0.002	>3	36.3	60.01	0.012
>2	25.1	25.94	0.350	>2	29.6	34.71	0.055	>2	33.6	33.40	0.076
>1	10.7	8.87	0.749	>1	15.5	13.97	0.298	>1	9.0	9.20	0.720
>0	3.6	2.17	0.743	>0	6.6	4.02	0.421	>0	6.0	3.66	0.476

Notes: This table reports the ADF statistics for testing the null that  $\varepsilon_{ijt}$  is not a stationary process. \* and \*\* denote significance at the 5 percent and 1 percent levels, respectively. The estimated equations are (lag structure for B(L) selected according to the BIC as before):

For the group of all 10 countries, the test rejects the null hypothesis that there are more than eight unit roots (at the 5 percent confidence level), but not more than seven unit roots. This result suggests the existence of eight common stochastic output trends for the 10 countries (that is, two cointegrating relationships, as the long-run impact matrix  $\Pi$  has two non-zero eigenvalues). In addition, although common long-run processes seem to be driving output in South America, the number of processes is still relatively high for achieving convergence in living standards.

These results do not significantly change when Venezuela is excluded from the sample; Johansen's test supports the existence of seven common trends for the subsample of nine countries. A similar result (not shown in Table 7) is obtained when excluding Colombia from the sample. On the contrary, the exclusion of both Colombia and Venezuela increases the relative number of found common long-run processes (seven for the group of eight countries). The fact that the relative number of common trends remains unchanged after the exclusion of a single member, Venezuela or Colombia in turn, suggests that neither country alone influences the meeting of the common integration goal. However, both countries do make a difference.

For the Mercosur and CAN member subgroups, similar evidence is found for each subset. The null that there are more than three common unit roots is rejected, while the null that there are more than two is not. Three common long-run trends seem to guide the output in each separate four-member subgroup. Compared with the whole sample, the relative number of long-run processes driving output in the selected subsamples is larger. This finding supports the hypothesis that separate Unasur members do not perform as well as they do jointly. The same result is found for the subset formed by Mercosur and CAN members plus Chile and Venezuela.

The large number of common trends shown by Johansen's multivariate test supports the conclusion that the output series in South America are not converging. If any sign of convergence were to be present, the test statistics would confirm the existence of a single common trend for each group of countries.

## **5. Conclusions**

A common objective drives the individual actions of South American countries since they have committed to the region's integration process, the primary goal of which is the elimination of disparities among citizens' living standards. Such an ambitious aim was interpreted herein as the achievement of convergence in the real per-capita output series of the individual countries in the region. In order to evaluate the evolution of the region towards this goal, the definitions of convergence and common stochastic trends proposed by Bernard and Durlauf (1995) were used to conduct unit root and cointegration tests for 10 of the 12 Unasur members: Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Peru, Paraguay, Uruguay, and Venezuela. Log real per-capita GDP was assumed to be a proxy measure of regional living standards.

The pairwise and multivariate evidence presented shows the existence of a relatively large number of common long-run trends driving output in South America, thereby rejecting the convergence hypothesis for the continent. Although this evidence suggests that Unasur is not yet achieving its objective, the existence of common long-run processes in output also suggests that economic growth in individual Unasur members does not respond exclusively to idiosyncratic, country-specific factors but also to the overarching common objective.

The opposing ideologies of South American countries' leaders have resulted in multiple integration projects across Unasur, and this division is reflected in the pairwise results at the subgroup level. Nevertheless, long-run similarities do still exist across South American countries. Indeed, the multivariate results support Sanahuja (2012)'s affirmation that Unasur acts a conciliator for the region's partners. However, additional regional policies are still necessary to reduce income inequalities further.

While this paper provided a number of preliminary results, using a richer dataset (beyond 2011) would improve our understanding of the convergence dynamics among the output series of Unasur members. Most sophisticated econometric methodologies could overcome the difficulty of the recentness of the analyzed South American integration project. This task, however, is left for future research.

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