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C32, O40, O54

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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.

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## 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>1</sup>.

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>2</sup>.

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<sup>1</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,

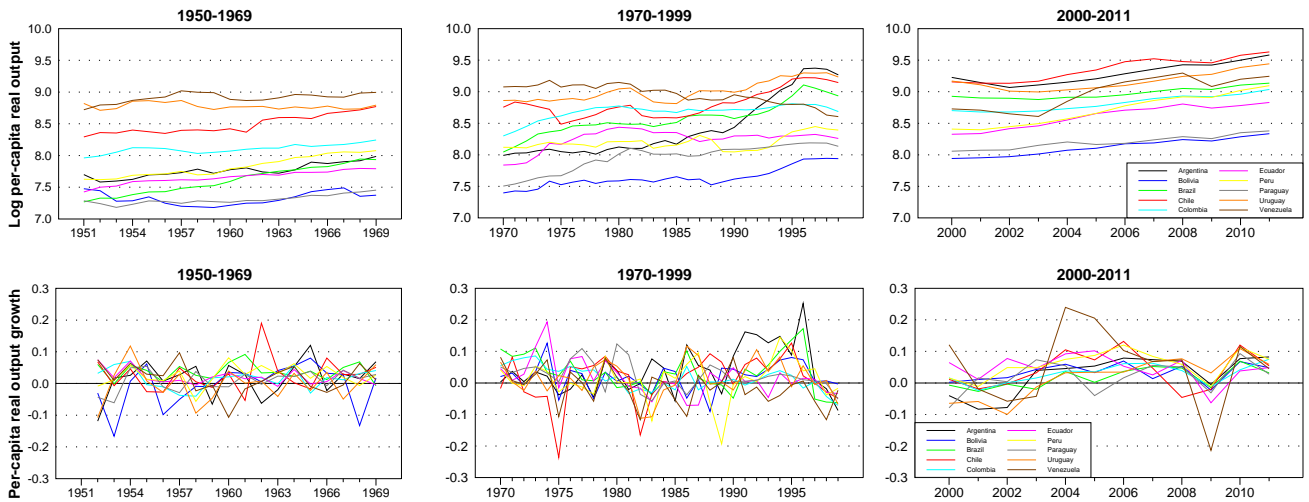


Figure 1: *Real output per-capita: 1951–2011*

Figure 1 shows that 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.

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>3</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 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).

was ratified by all signatory countries in 2011.

<sup>2</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>3</sup>See Art. 2 of the Constitutive Treaty of Unasur.

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 all economies should eventually converge (Barro and Sala-i-Martin, 2004). The convergence hypothesis has attracted vast research interest (Barro and Sala-i-Martin, 1991, Baumol, 1986, Mankiw et al., 1992, Pritchett, 1997). 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, Temple, 1999, 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 is divided 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>4</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 1960–1900 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 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>5</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

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<sup>4</sup>The countries included in this study are Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Paraguay, Peru, Uruguay, and Venezuela.

<sup>5</sup>This fact is also true for other works that have explored convergence issues in Latin America (Engle and Issler, 1993, Holmes, 2005, 2006).

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>6</sup>. Previous studies have mainly addressed groups of developed countries such as the OECD (Cerqueira and Martins, 2009, Déés and Zorell, 2012, Kappler and Sachs, 2013, among others), G7 (Artis et al., 1997, Canova et al., 2007, Kose et al., 2003, among others), and European Monetary Union (Antonakakis and Tondl, 2014, Crespo-Cuaresma and Fernández-Amador, 2013, Lee, 2013, among others) as well as countries belonging to a trade agreement or a currency union<sup>7</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, Busse et al., 2006, Gimet, 2007), 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, Lumsdaine and Prasad, 2003) or calculate concordance indexes and correlations of business cycle timings across countries without imposing a common cycle (Harding and Pagan, 2006, 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, Dellas, 1986, Fabrizio and Lopez, 1996, Jackman and Moore, 2008, Loayza et al., 2001)<sup>8</sup>. Because the simi-

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<sup>6</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>7</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, Kishor and Ssozi, 2011, Nguyen et al., 2014).

<sup>8</sup>Optimum currency area theory asserts that countries facing symmetric shocks are better candidates to form a monetary union.

larity 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, Gimet, 2007, Izquierdo et al., 2008, 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).

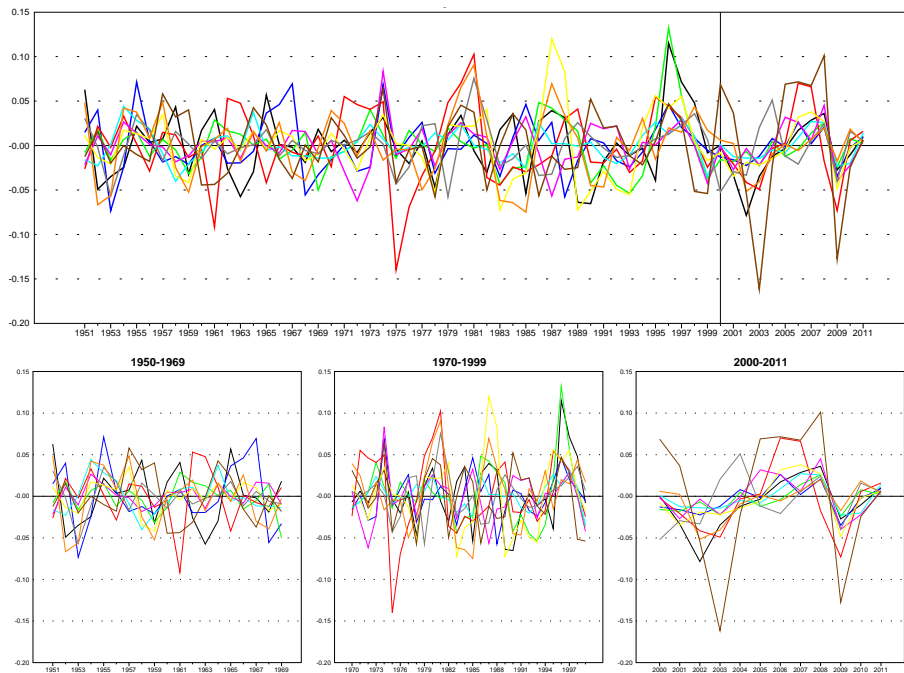


Figure 2: *Business cycles: 1951–2011. HP-filtered. Dampening value  $\lambda$  set to 6.25*

<i>Business cycle pairwise correlations</i>							
	<i>All</i>	<i>1951–1960</i>	<i>1961–1970</i>	<i>1971–1980</i>	<i>1981–1990</i>	<i>1991–2000</i>	<i>2001–2011</i>
<i>Average</i>	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.

Table 1: *Average pairwise correlations of business cycles.*

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 approach

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>9</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, Mankiw et al., 1992) or that some measure of income dispersion is decreasing over time ( $\alpha$ -convergence) (Cannon and Duck, 2000, Friedman, 1992). Subsequent empirical research has described the main drawbacks of such static methods (Durlauf et al., 2005, Temple, 1999) and propose several alternative approaches for analyzing this issue, such as distribution dynamics (Quah, 1993, 1996, 1997), state space models (Bulli, 2001, Johnson, 2005), time series approaches (Bernard and Durlauf, 1995, 1996, Hobijn and Franses, 2000), panel data models (Evans, 1998, Islam, 1995), event study approaches (Pritchett, 2000), and nonlinear tests (Enders and Lee, 2012)<sup>10</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 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.

The convergence hypothesis includes three (compelling) hypotheses: i) the *absolute convergence hypothesis*, namely the long-run convergence of per-capita incomes between countries independent of their initial conditions, ii) the *conditional convergence hypothesis*, namely the long-run convergence of per-capita incomes between countries that have identical structural characteristics (preferences, technologies, rates of population growth, government policies,

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<sup>9</sup>See Barro and Sala-i-Martin (2004), Durlauf et al. (2005), Islam (2003), Temple (1999) for reviews of the convergence literature.

<sup>10</sup>Only the pioneering studies are mentioned here to save space.



among others) independent of their initial conditions, and iii) the *club convergence hypothesis*, which asserts that the per-capita incomes of countries that have identical structural characteristics converge in the long run provided that their initial conditions are similar as well. Despite the notable efforts of the convergence literature, the validity of these three hypotheses remains an open question.

### 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

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

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>11</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 Definitions A.1. and A.2., 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>12</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.

### 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>13</sup>. These data are derived from the Penn World Tables 8.0 and cover the period 1951 to 2011<sup>14</sup>. The tests of convergence and common trends follow the procedures developed by [Engle and Granger \(1987\)](#) and [Johansen \(1988, 1991\)](#). Uncovering the presence of unit roots in individual output series relies on the traditional augmented Dickey–Fuller (ADF) and Phillips–Perron (PP) tests.

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<sup>11</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>12</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.

<sup>13</sup>Surinam and Guyana are not included owing to data availability. The sample thus represents 10 of the 12 Unasur members.

<sup>14</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.

Definition	Cointegration equivalent
<p><b>A.1. Convergence in output</b>  Countries <math>i</math> and <math>j</math> converge if the long-term forecasts of output for both countries are equal at a fixed time <math>t</math>:</p> $\lim_{k \rightarrow \infty} E(y_{i,t+k} - y_{j,t+k}   I_t) = 0$	<p>Countries <math>i</math> and <math>j</math> converge if their output series are cointegrated with the cointegrating vector <math>[1,-1]</math></p>
<p><b>A.2. Convergence in multivariate output</b>  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>. Alternatively, the output deviations from the benchmark country (<math>y_{1,t+k} - y_{p,t+k}</math>) must be a zero-mean stationary process.</p>
<p><b>B.1. Common trends in output</b>  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,-\alpha]</math></p>
<p><b>B.2. Common trends in multivariate output</b>  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>\tilde{y}_t = [y_{2,t}, y_{3,t}, \dots, y_{p,t}]</math>:</p> $\lim_{k \rightarrow \infty} E(y_{1,t+k} - \alpha'_p \tilde{y}_{t+k}   I_t) = 0$	<p>All <math>p</math> countries share a single common stochastic trend if there exists just one cointegrating relation between them.</p>

Table 2: Bernard and Durlauf's (1995) definitions of convergence and common trends in output

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  $Y_t$  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

$$\Delta Y_t = \mu + C(L)\varepsilon_t. \quad (2)$$

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

$$y_{1,t} = \alpha_0 + \alpha_1 y_{2,t} + \dots + \alpha_{n-1} y_{n,t} + \varepsilon_t^{15}, \quad (3)$$

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

$$\Delta \varepsilon_t = -\theta \varepsilon_{t-1} + B(L) \Delta \varepsilon_t + \varsigma_t^{16},$$

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>17</sup>. Because of this shortcoming, the Johansen (1988, 1991) technique is also applied. Johansen's (1988, 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

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

and

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

$\Gamma(L)$  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 (1988, 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>18</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  $\hat{\Pi}$  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  $\hat{\lambda}_1 > \hat{\lambda}_2 > \dots > \hat{\lambda}_p$  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  $\hat{\Pi}$  is of full rank,  $p$ , no characteristic root will be equal to zero. If instead  $\hat{\Pi}$ '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 the rank is  $p$ . For the maximum eigenvalue statistic, the null and alternative hypotheses are that the rank is  $r$  and  $r + 1$ , respectively.

<sup>15</sup>This is called a cointegrating regression because it represents the long-run relationship between the variables.

<sup>16</sup>This specification allows for non-white noise  $\varepsilon_t$  residuals.

<sup>17</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>18</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.

## Bivariate 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  $\widehat{\varepsilon}_{ij,t}$ . The stationarity of  $\widehat{\varepsilon}_{ij,t}$  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>19</sup>.

## Multivariate test

The multivariate convergence and common trends for the 10 Unasur countries are tested by using Johansen's (1988, 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.  $\mu t = 0$  (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

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

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>20</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 (1988) methodology is employed (Definition B.2.).

<sup>19</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  $y_{i,t} - y_{j,t}$ .

<sup>20</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.

**Log GDP Per-capita**  
**Level and differenced series**

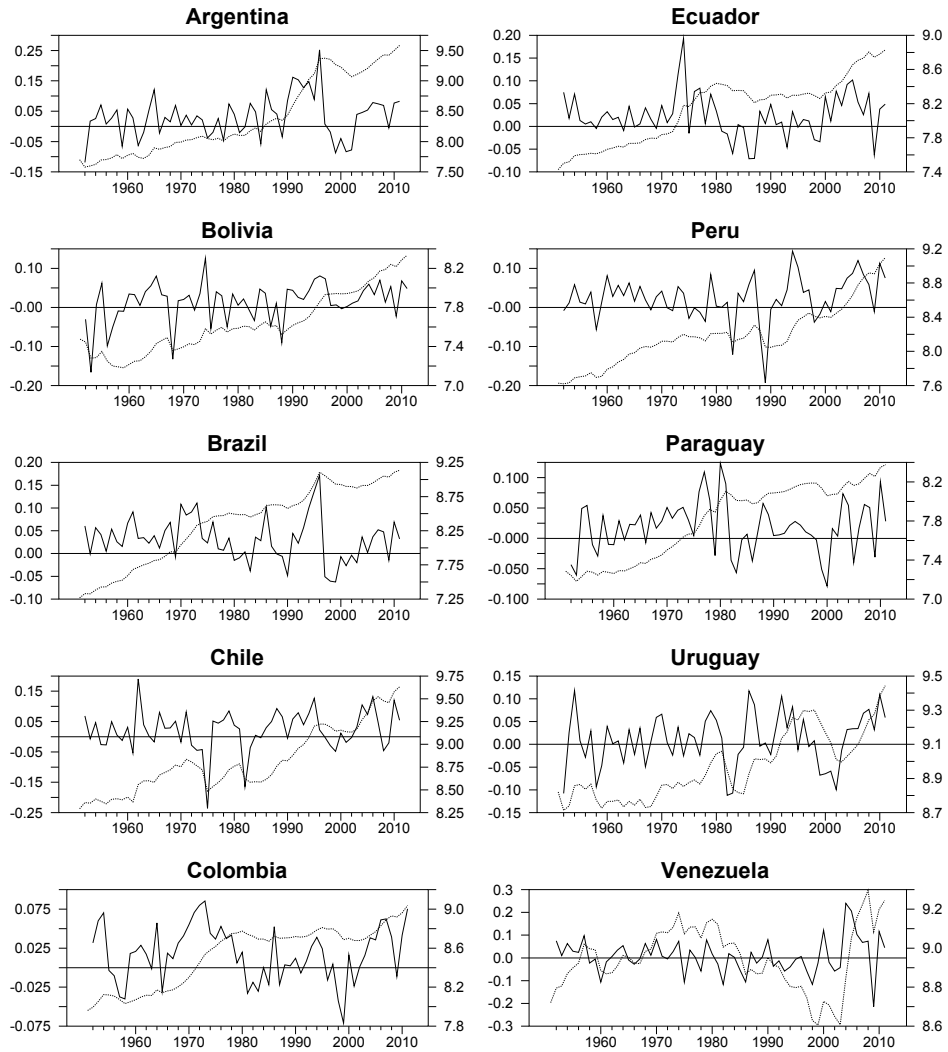


Figure 3: *Log per-capita output of the 10 Unasur countries. Level and growth series. 1951–2011*

## 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.

	ADF		PP	
	Level ( $Y_t$ )	First differences ( $\Delta Y_t$ )	Level ( $Y_t$ )	First 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.

Table 3: *Unit root test. Log real per-capita output*

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.

### 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 to be a stationary process; in other words, the differences in pairwise living standards within Unasur are permanent<sup>21</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).

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

<sup>21</sup>This result supports historical evidence for some Latin American countries. Dobson and Ramlogan (2010) find no evidence on  $\beta$ -convergence between a set of 19 Latin American countries (including the 10 under study herein).

	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  $\varepsilon_{ij,t} = y_{i,t} - y_{j,t}$  is not a stationary process. The estimated equations, whose lag structure is chosen according to the BIC, are

$$\Delta\varepsilon_{ij,t} = -\theta_{ij}\varepsilon_{ij,t} + B(L)\Delta\varepsilon_{ij,t} + \varsigma_{ij,t}.$$

Table 4: *Pairwise convergence tests for the 10 Unasur countries: 1951–2011*

seems to be driven by a common process, supporting the belief that output growth across some pairs of South American countries shares common elements.

	AR	BO	BR	CH	CO	EC	PE	PA	UR
AR	–								
BO	-2.396*	–							
BR	-0.619	-1.684	–						
CH	-2.425*	-3.385**	-1.336	–					
CO	-1.462	-1.412	-1.386	-0.591	–				
EC	-1.389	-2.103*	-2.090*	-1.584	-1.749	–			
PE	-1.106	-3.104**	-0.405	-2.072*	-1.267	-2.054*	–		
PA	-1.075	-0.908	-2.720**	-0.710	-2.753**	-2.135*	-0.227	–	
UR	-2.891**	-2.765**	-2.088*	-2.305*	-1.875	-2.199*	-1.644	-2.105*	–
VE	0.037	1.118	-1.068	0.240	-0.920	-0.742	-0.382	-0.708	-1.047

*Notes:* This table reports the ADF statistics for testing the null that  $\varepsilon_{ij,t}$  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)

$$y_{i,t} = c_{ij} + \alpha_{ij}y_{j,t} + \varepsilon_{ij,t}$$

$$\Delta\varepsilon_{ij,t} = -\theta_{ij}\varepsilon_{ij,t} + B(L)\Delta\varepsilon_{ij,t} + \varsigma_{ij,t}.$$

Table 5: *Pairwise cointegration tests for the 10 Unasur countries: 1951–2011*

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>22</sup>. Figure 4 presents the increasing prevalence of integration agreements among South American countries. By 2000, Mercosur (Argentina,

<sup>22</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.

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>23</sup>. At the time of its creation, Unasur joined Mercosur, CAN, 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>24</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.

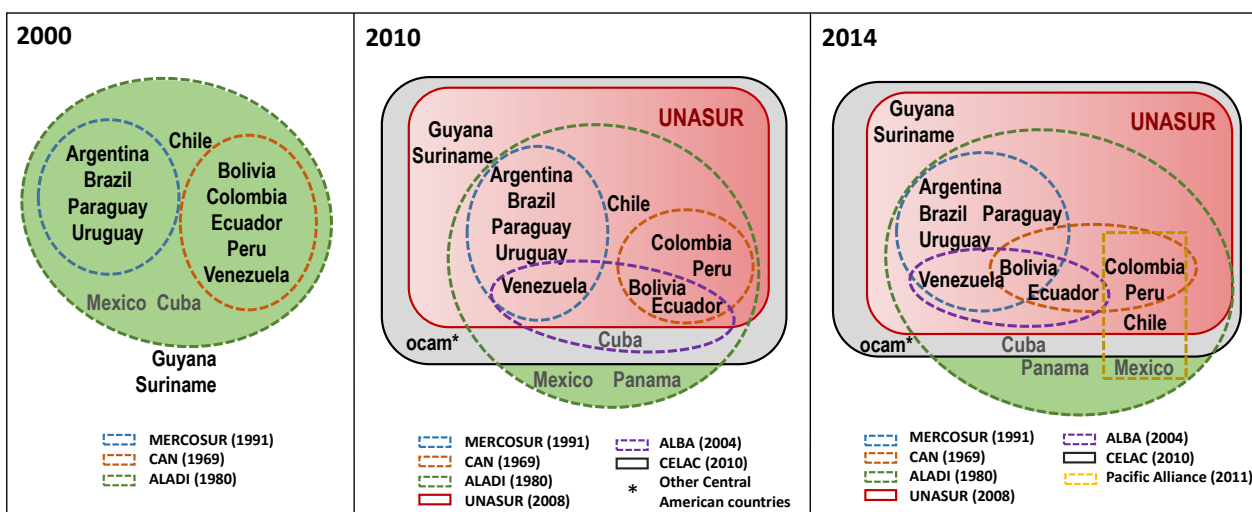


Figure 4: *Regional integration blocs in South America*

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>25</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

<sup>23</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).

<sup>24</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>25</sup>Venezuela has been a Mercosur member since 2006, Bolivia since 2012, and Ecuador has started the process of accession.



of a disagreement over Colombia and Peru’s relationships with the United States<sup>26</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 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. Table 6 summarizes these findings and displays the number of significant cointegrating relations; X in  $x_{ij}$  denotes that the output levels of countries  $i$  and  $j$  are cointegrated. 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 4.3.

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 4.3).

i\j	Unasur									
	Mercosur				CAN					
	AR	BR	PA	UR	BO	CO	EC	PE	CH	VE
AR	–	–	–	X	X	–	–	–	X	–
BR	–	–	X	X	–	–	X	–	–	–
PA	–	X	–	X	–	X	X	–	–	–
UR	X	X	X	–	X	–	X	–	X	–
	1	2	2	3						
BO	X	–	–	X	–	–	X	X	X	–
CO	–	–	X	–	–	–	–	–	–	–
EC	–	X	X	X	X	–	–	X	–	–
PE	–	–	–	–	X	–	X	–	X	–
					2	0	2	2		
CH	X	–	–	X	X	–	–	X	–	–
	3	3	4	6	5	1	5	3	4	0

*Notes:* The table summarizes the pairwise cointegration evidence. X in  $x_{ij}$  denotes that the output levels of countries  $i$  and  $j$  passed the cointegration test.

Table 6: *Pairwise cointegration*

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>27</sup>. Multivariate convergence is only tested for the

<sup>26</sup>Hugo Chavez, Venezuela’s president at that time, was the architect of ALBA.

<sup>27</sup>The output series of Mercosur and CAN are computed as the aggregation of their members’ output.

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 Rolling cointegration analysis

In order to obtain time-varying information about the pairwise common trends just described, the rolling cointegration method, typically used in a multivariate context (Awokuse et al., 2009, Brada et al., 2005, Mylonidis and Kollias, 2010, among others), is adapted for the bivariate approach used herein. The test statistics are calculated for a rolling 49-year fixed length window. That is, starting with observations 1–49 (subperiod 1951–1999), the cointegrating regression  $y_{i,t} = c_{ij} + \alpha_{ij}y_{j,t} + \varepsilon_{ij,t}$  is estimated. Then, the stationarity of the residuals  $\hat{\varepsilon}_t$  is tested by using ADF statistics for the null  $\theta = 0$  from the regression  $\Delta\varepsilon_t = -\theta\varepsilon_{t-1} + B(L)\Delta\varepsilon_t + \zeta_t$ . The same procedure is then carried out for observations 2–50 (subperiod 1952–2000), 3–51 (subperiod 1953–2001), and so on up to subperiod 1999–2011 (13 subperiods in total)<sup>28</sup>. This exercise is repeated for each of the 45 pairs of countries and reported in a continuous plot of the obtained ADF statistics by country.

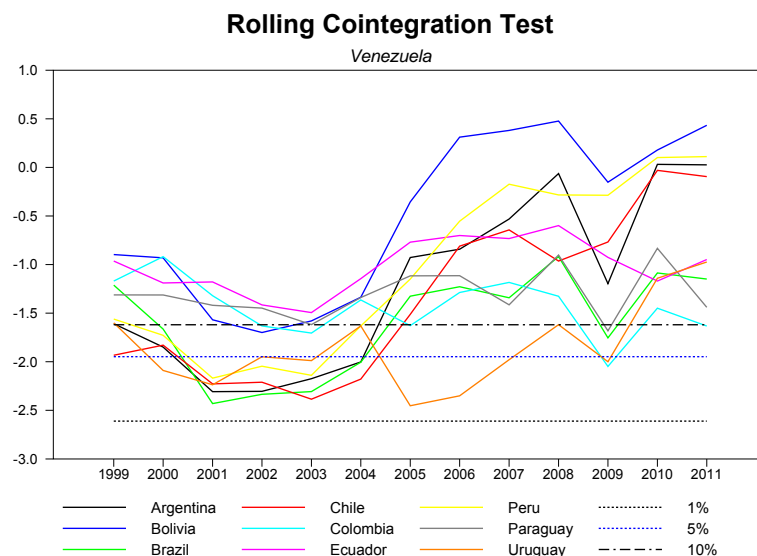


Figure 5: ADF statistics for the residuals of the cointegration regression (49-year fixed length window). All country pairings that include Venezuela.

Figure 5 illustrates the time-varying pattern of the stochastic long-run relationship between Venezuela (the least cointegrated country) and each of the other analyzed Unasur members' output. For instance, the blue line in Figure 5 plots the time evolution of the ADF statistic corresponding to the cointegrating relationship between Venezuela and Bolivia, while the three horizontal straight lines delimit the rejection region of the test corresponding (from top to bottom) to the 10, 5, and 1 percent critical values, respectively. Then, a value of the test statistic (for example, the Venezuela–Bolivia timeline) above the critical values means that

<sup>28</sup>This rolling cointegration exercise is not performed in a multivariate context because of the lack of degrees of freedom in the entire sample.

the corresponding null hypothesis (existence of a common stochastic trend in output between Venezuela and Bolivia) can be rejected at the 10, 5, and 1 percent levels for the specified subsample period, respectively. The figure reports the test statistics for the last year of the rolling sample period from which they are derived. In the case of Venezuela, this exercise not only confirms its weak connection with the other South American countries but also shows that this pattern is stronger after 2004, the year in which ALBA was created. Indeed, as suggested by the results, Venezuela's citizens shared common trends in living standards with those from Argentina, Brazil, Chile, and Uruguay until 2004 (the ADF statistics are below the 5 percent critical value), and this evolved towards the elimination of such common trends, namely the rejection of the null of cointegration with all countries. It is tempting to explain this pattern on the basis of oil price changes (Venezuela was the first oil exporter in South America); however, it is worth noting that the GDP series used herein are not PPI- but CPI-based and corrected for population and inflationary effects (log real GDP per-capita in 2005 PPP-adjusted dollars). Therefore, they do not reflect supply-side but rather purchasing power effects.

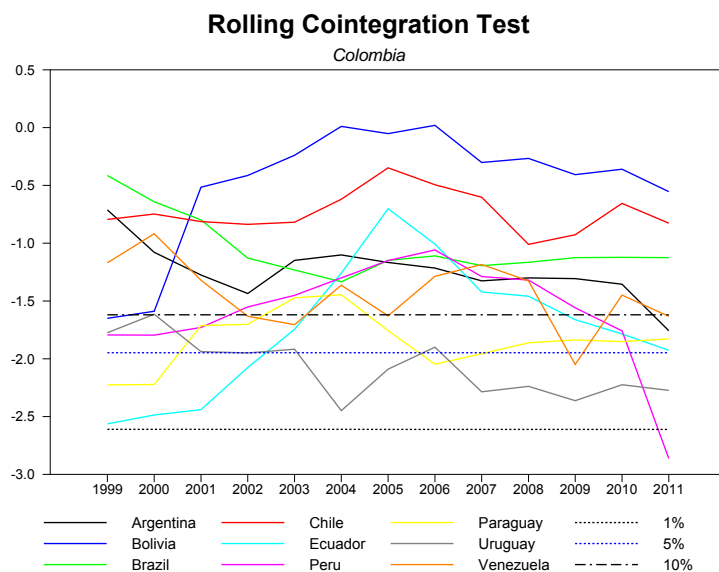


Figure 6: *ADF statistics for the residuals of the cointegration regression (49-year fixed length window). All country pairings that include Colombia.*

As evidenced by Figure 6, and contrary to Venezuela's pattern, the test statistics corresponding to the pairs formed by Colombia, the second least cointegrated country (see Table 6), and the other Unasur members evolve towards the non-rejection of the null hypothesis, notably the Colombia–Peru relation. Remember that both Colombia and Peru belong to the Pacific Alliance and that by signing free trade agreements with the United States, they both expressed an opposed ideological trend to ALBA and Unasur members.

The Venezuelan and Colombian examples confirm the major influence of the different South American integration projects on the achievement of Unasur's objective of promoting growth and reducing income inequalities. The contradictory actions of the abovementioned subgroups create negative pairwise dynamics for the accomplishment of convergence in per-capita income within Unasur. Therefore, the actions of all the subgroups formed by South American countries must converge prior to the attainment of Unasur's objective. Hence, additional effort is required to ensure that Unasur's short-run actions dominate the region's pattern of convergence and reflect in the long-run closure of the gap between the living standards across South America.

The time-varying pairwise patterns of Argentina, Bolivia, Brazil, Chile, Ecuador, Paraguay, Peru, and Uruguay are illustrated in Figures 9 and 10 in the appendix. Such a unanimous

	1980	1985	1990	1995	2000	2005	2010	2013
Argentina	15.81	13.67	12.04	13.56	13.91	13.3	14.00	14.31
Bolivia	0.58	0.52	0.52	0.52	0.56	0.56	0.57	0.61
Brazil	53.85	55.87	55.69	53.08	52.98	52.65	52.30	50.42
Chile	3.94	4.05	5.06	6.29	6.97	7.42	7.04	7.40
Colombia	6.95	7.64	8.77	8.80	8.45	8.74	8.72	9.13
Ecuador	2.17	2.41	2.49	2.36	2.25	2.47	2.32	2.48
Guyana	0.07	0.05	0.04	0.05	0.05	0.04	0.04	0.04
Paraguay	0.43	0.48	0.58	0.59	0.54	0.52	0.53	0.56
Peru	4.62	4.61	3.78	4.05	4.13	4.42	4.93	5.33
Suriname	0.14	0.13	0.11	0.09	0.09	0.10	0.10	0.10
Uruguay	1.29	1.05	1.14	1.13	1.18	1.03	1.09	1.14
Venezuela	10.08	9.46	9.70	9.42	8.83	8.68	8.32	8.41

*Source:* World Bank national accounts data and OECD National Accounts data files. Series of GDP per-capita (constant 2005 US\$).

Table 7: *GDP share by member country of total Unasur GDP.*

trend towards the rejection of the cointegration null hypothesis, as the shown by the Venezuelan pattern in Figure 5, is not reproduced by any other country. These results suggest a number of future challenges for meeting the integration goal. First, the output levels of Argentina and Brazil, the largest economies of South America, are not cointegrated. Because these countries have historically contributed over 50 percent of the region’s GDP (see Table 7), a conflict between them is likely to affect the entire region. Second, Brazil, the originator and main supporter of the South American integration initiative, shares a stochastic trend in output with only three of the nine countries. The pro-integration political leadership in Brazil is thus not reflected in a pairwise relationship with the other members of the bloc. Finally, Figure 10 shows that in the wake of the signature of the Peru–United States free trade agreement in 2006, Peru’s pairwise relationship with its Unasur partners moves away from the non-rejection area of the test (below the critical values forming the confidence band). Only the Peru–Colombia pair evolves downward, reaching the non-rejection area and sharing a common stochastic trend in output at the end of the period. This finding reconfirms the influence of alternative blocs such as the Pacific Alliance.

Further, the country pairings formed by the combination of Bolivia, Ecuador, and Venezuela (all ALBA members) neither share a common trend in output (Table 6) nor display a time-varying pattern towards the statistical non-rejection of such a common trend. Hence, ALBA does not seem to be progressing towards long-run income convergence.

Although pairwise analysis is useful to explain the behavior of output series, however, multivariate analysis is necessary to capture the richer dynamic of the data and to provide more realistic information about the convergence in output within the analyzed countries.

### 4.3 Multivariate 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

### Output Gap: 1951-2011

Uruguay as benchmark country

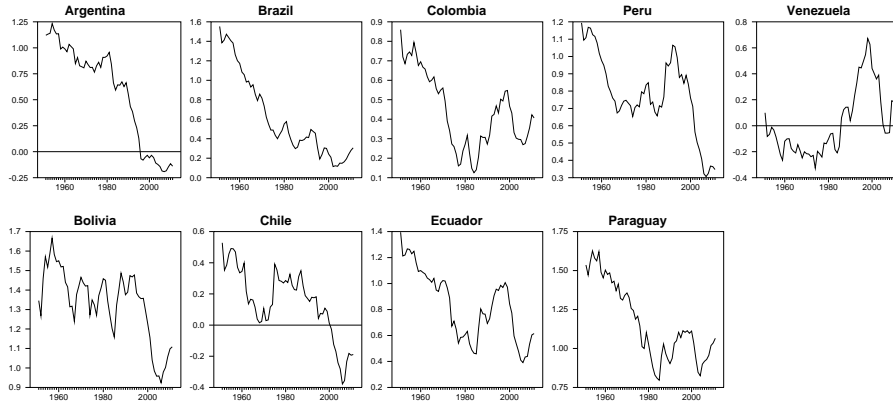


Figure 7: *Output deviations from Uruguay*

stochastic trends with the other analyzed Unasur members<sup>29</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 presented results. Figure 7 illustrates the dynamic evolution of the output deviations, with no signals of stationarity reported. Indeed, the ADF and PP statistics presented in Table 8 confirm our non-convergence expectations<sup>30</sup>.

	$Dy_{i,t}$	
	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.

Table 8: *Multivariate convergence. Ten Unasur countries.*

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 9 for each of the six subsets of countries defined previously, and Figure 8 illustrates the output series by subgroup. The lag structure was chosen by using the BIC, with a lag length of one describing the dynamics of the system.

<sup>29</sup>These results hold for any other choice of benchmark country.

<sup>30</sup>Several authors have tested the convergence hypothesis for European countries, concluding that their output does not converge (Bernard and Durlauf, 1995, Beyaert and Camacho, 2008, 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.

## Log GDP Per-capita: 1951-2011

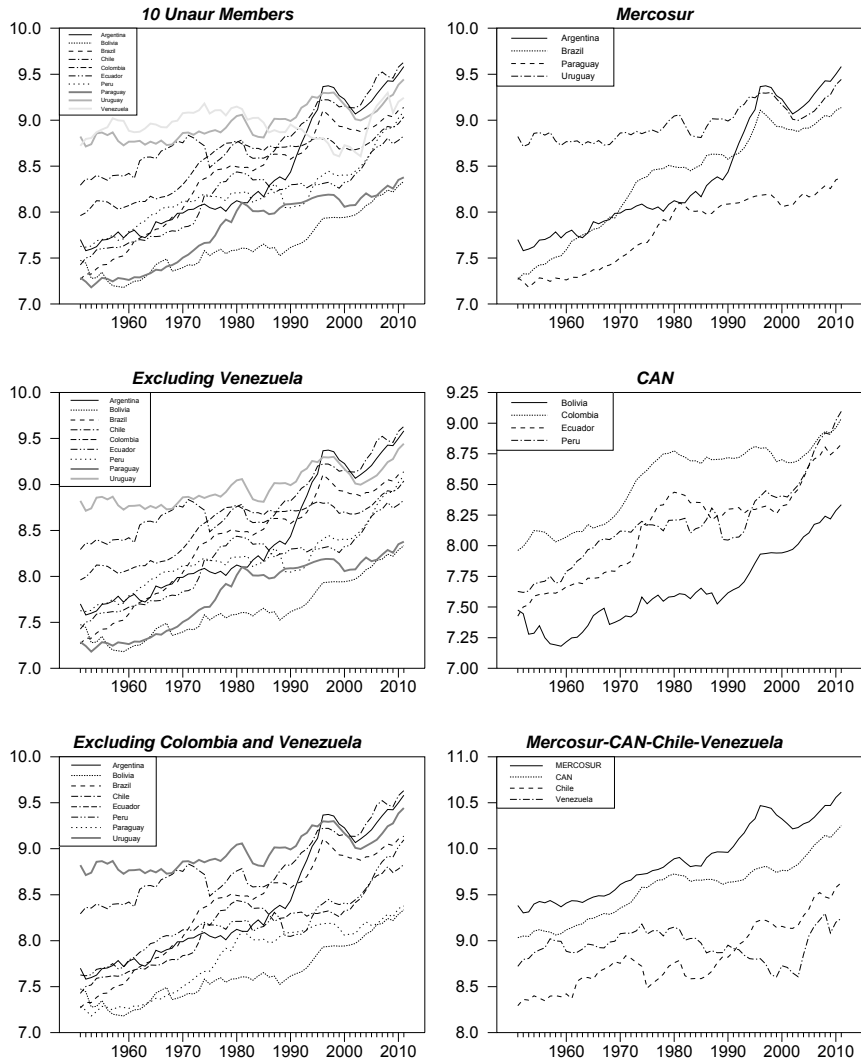


Figure 8: *Subsets of Unasur countries*

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.

Trends				Trends				Trends			
$p - r$	<i>All</i>			$p - r$	<i>Excluding Venezuela</i>			$p - r$	<i>Excl. Venez. and Colombia</i>		
	M.Eig.	Trace	P-Val		M.Eig.	Trace	P-Val		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				Trends				Trends			
$p - r$	<i>MER+CAN+Ch+Ve</i>			$p - r$	<i>Mercosur</i>			$p - r$	<i>CAN</i>		
	M.Eig.	Trace	P-Val		M.Eig.	Trace	P-Val		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

Table 9: *Multivariate tests for cointegration (VAR lag length = 1)*

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 9) 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.

## References

- Abramovitz, M. (1986), 'Catching up, forging ahead, and falling behind', *The Journal of Economic History* **46**(2), 385–406.
- Aiolfi, M., Catao, L. and Timmermann, A. (2011), 'Common factors in latin america's business cycles', *Journal of Development Economics* **95**(2), 212–228.
- Albertoni, N. (2012), 'Integración económica para américa latina', *Diálogo Político* **3**, 195–215.
- Allegret, J.-P. and Sand, A. (2009), 'Modeling the impact of real and financial shocks on mercosur: The role of the exchange rate regime', *Open Economies Review* **20**(3), 359–384.
- Antonakakis, N. and Tondl, G. (2014), 'Does integration and economic policy coordination promote business cycle synchronization in the eu?', *Empirica* **41**(3), 541–575.
- Artis, M., Kontolemis, Z. and Osborn, D. (1997), 'Business cycles for g7 and european countries', *The Journal of Business* **70**(2), 249–279.
- Awokuse, T., Chopra, A. and Bessler, D. (2009), 'Structural change and international stock market interdependence: Evidence from asian emerging markets', *Economic Modelling* **26**(3), 549–559.



- Babetskii, I. (2005), 'Trade integration and synchronization of shocks', *Economics of Transition* **13**, 105–138.
- Barro, R. and Sala-i-Martin, X. (1991), 'Convergence across states and regions', *Brookings Papers on Economic Activity* **22**(1), 107–182.
- Barro, R. and Sala-i-Martin, X. (1992), 'Convergence', *Journal of Political Economy* **100**(2), 223–51.
- Barro, R. and Sala-i-Martin, X. (1997), 'Technological diffusion, convergence, and growth', *Journal of Economic Growth* **2**(1), 1–26.
- Barro, R. and Sala-i-Martin, X. (2004), *Economic Growth*, Massachusetts Institute of Technology.
- Baumol, W. (1986), 'Productivity growth, convergence, and welfare: What the long-run data show', *American Economic Review* **76**(5), 1072–85.
- Bernard, A. and Durlauf, S. (1995), 'Convergence in international output', *Journal of Applied Econometrics* **10**(2), 97–108.
- Bernard, A. and Durlauf, S. (1996), 'Interpreting tests of the convergence hypothesis', *Journal of Econometrics* **71**(1–2), 161–173.
- Beyaert, A. and Camacho, M. (2008), 'Tar panel unit root tests and real convergence', *Review of Development Economics* **12**(3), 668–681.
- Bonilla-Bolaños, A. (2014), 'External vulnerabilities and economic integration: Is the union of south american nations a promising project?', *Journal of Economic Development* **39**, 97–131.
- Boonman, T., Kuper, G. and Jacobs, J. (2012), The global financial crisis and currency crises in latin america, Research Report 12005-EEF, University of Groningen, Research Institute SOM (Systems, Organisations and Management).
- Bordo, M. and Helbling, T. (2011), 'International business cycle synchronization in historical perspective', *The Manchester School* **79**(2), 208–238.
- Brada, J., Kutan, A. and Zhou, S. (2005), 'Real and monetary convergence between the european union's core and recent member countries: A rolling cointegration approach', *Journal of Banking and Finance* **29**(1), 249–270.
- Briceño-Ruiz, J. (2014), Regional dynamics and external influences in the discussions about the model of economic integration in latin america, Eui working paper rscas 2014/11, Robert Schuman Centre for Advanced Studies.
- Bulli, S. (2001), 'Distribution dynamics and cross-country convergence: A new approach', *Scottish Journal of Political Economy* **48**(2), 226–243.
- Busse, M., Hefeker, C. and Koopmann, G. (2006), 'Between two poles: A dual currency board for mercosur', *The North American Journal of Economics and Finance* **17**(3), 349–362.
- Cannon, E. and Duck, N. (2000), 'Galton's fallacy and economic convergence', *Oxford Economic Papers* **52**(2), 415–19.
- Canova, F. (2005), 'The transmission of us shocks to latin america', *Journal of Applied Econometrics* **20**(2), 229–251.

- Canova, F., Ciccarelli, M. and Ortega, E. (2007), ‘Similarities and convergence in g-7 cycles’, *Journal of Monetary Economics* **54**(3), 850–878.
- Cerqueira, P. A. and Martins, R. (2009), ‘Measuring the determinants of business cycle synchronization using a panel approach’, *Economics Letters* **102**(2), 106–108.
- Crespo-Cuaresma, J. and Fernández-Amador, O. (2013), ‘Business cycle convergence in emu: A second look at the second moment’, *Journal of International Money and Finance* **37**(0), 239–259.
- Crowley, P. M. and Schultz, A. (2010), Measuring the intermittent synchronicity of macroeconomic growth in europe, Working Paper 2010.1, American Consortium on European Union Studies (ACES).
- Dellas, H. (1986), ‘A real model of the world business cycle’, *Journal of International Money and Finance* **5**(3), 381–394.
- Dées, S. and Zorell, N. (2012), ‘Business cycle synchronisation: Disentangling trade and financial linkages’, *Open Economies Review* **23**(4), 623–643.
- Dobson, S. and Ramlogan, C. (2002a), ‘Convergence and divergence in latin america, 1970-1998’, *Applied Economics* **34**(4), 465–470.
- Dobson, S. and Ramlogan, C. (2002b), ‘Economic growth and convergence in latin america’, *Journal of Development Studies* **38**(6), 83–104.
- Durlauf, S., Johnson, P. and Temple, J. (2005), *Handbook of Economic Growth*, Elsevier.
- Enders, W. and Lee, J. (2012), ‘A unit root test using a fourier series to approximate smooth breaks’, *Oxford Bulletin of Economics and Statistics* **74**(4), 574–599.
- Engle, R. F. and Issler, J. V. (1993), ‘Common trends and common cycles in latin america’, *Revista Brasileira de Economia* **47**, 149–76.
- Engle, R. and Granger, C. (1987), ‘Cointegration and error correction: Representation, estimation, and testing’, *Econometrica* **55**(2), 251–76.
- Evans, P. (1998), ‘Using panel data to evaluate growth theories’, *International Economic Review* **39**(2), 295–306.
- Fabrizio, S. and Lopez, H. (1996), Domestic, foreign or common shocks?, IMF Working Papers 96/107, International Monetary Fund.
- Friedman, M. (1992), ‘Do old fallacies ever die?’, *Journal of Economic Literature* **30**(4), 2129–32.
- Galvao, A. and Reis-Gomes, F. (2007), ‘Convergence or divergence in latin america? a time series analysis’, *Applied Economics* **39**(11), 1353–1360.
- Gimet, C. (2007), ‘Le projet d’union monétaire dans le mercosur: Etude de la position actuelle dans les pays par rapport à une carte de critères de soutenabilité’, *Brussels Economic Review* **50**(2), 249–273.
- Gong, C. and Kim, S. (2013), ‘Economic integration and business cycle synchronization in asia’, *Asian Economic Papers* **12**(1), 76–99.

- Harding, D. and Pagan, A. (2006), ‘Synchronization of cycles’, *Journal of Econometrics* **132**(1), 59–79.
- Hobijn, B. and Franses, P. H. (2000), ‘Asymptotically perfect and relative convergence of productivity’, *Journal of Applied Econometrics* **15**(1), 59–81.
- Holmes, M. (2005), ‘New evidence on long-run output convergence among latin american countries’, *Journal of Applied Economics* **8**, 299–319.
- Holmes, M. (2006), ‘Regimen-dependent output convergence in latin america’, *Estudios de Economia* **33**, 65–81.
- Islam, N. (1995), ‘Growth empirics: A panel data approach’, *The Quarterly Journal of Economics*, *MIT Press* **110**(4), 1127–70.
- Islam, N. (2003), ‘What have we learnt from the convergence debate?’, *Journal of Economic Surveys* **17**(3), 309–362.
- Izquierdo, A., Romero, R. and Talvi, E. (2008), Booms and busts in latin america: The role of external factors, Working paper, Inter-American Development Bank, Research Department 631, Washington, DC.
- Jackman, M. and Moore, W. (2008), ‘Economic policy co-movement in latin america and the caribbean’, *Journal of Policy Modeling* **30**(6), 1107–1114.
- Jara, A., Moreno, R. and Tovar, C. (2009), ‘The global crisis and latin america: financial impact and policy responses’, *BIS Quarterly Review* **June**, 53–68.
- Johansen, S. (1988), ‘Statistical analysis of cointegration vectors’, *Journal of Economic Dynamics and Control* **12**(2–3), 231–254.
- Johansen, S. (1991), ‘Estimation and hypothesis testing of cointegration vectors in gaussian vector autoregressive models’, *Econometrica* **59**(6), 1551–1580.
- Johansen, S. (1995), *Likelihood-Based Inference in Cointegrated Vector Autoregressive Models*, number 9780198774501 in ‘OUP Catalogue, Oxford University Press’, Oxford University Press.
- Johnson, P. (2005), ‘A continuous state space approach to ‘convergence by parts’’, *Economics Letters* **86**(3), 317–321.
- Kappler, M. and Sachs, A. (2013), Summary and policy implications, in M. Kappler and A. Sachs, eds, ‘Business Cycle Synchronisation and Economic Integration’, Vol. 45 of *ZEW Economic Studies*, Physica-Verlag HD, pp. 171–173.
- Kishor, N. and Ssozi, J. (2011), ‘Business cycle synchronization in the proposed east african monetary union: An unobserved component approach’, *Review of Development Economics* **15**(4), 664–675.
- Kose, A., Prasad, E. and Terrones, M. (2003), ‘How does globalization affect the synchronization of business cycles?’, *The American Economic Review* **93**(2), 57–62.
- Lee, J. (2013), ‘Business cycle synchronization in europe: Evidence from a dynamic factor model’, *International Economic Journal* **27**(3), 347–364.

- Loayza, N., Lopez, H. and Ubide, A. (2001), ‘Comovements and sectoral interdependence: Evidence for latin america, east asia, and europe’, *IMF Staff Papers* **48**(2), 367–396.
- Lumsdaine, R. and Prasad, E. (2003), ‘Identifying the common component of international economic fluctuations: A new approach’, *Economic Journal* **113**, 101–127.
- MacKinnon, J., Haug, A. and Michelis, L. (1999), ‘Numerical distribution functions of likelihood ratio tests for cointegration’, *Journal of Applied Econometrics* **14**(5), 563–77.
- Mackowiak, B. (2007), ‘External shocks, u.s. monetary policy and macroeconomic fluctuations in emerging markets’, *Journal of Monetary Economics* **54**(8), 2512–2520.
- Mankiw, G., Romer, D. and Weil, D. (1992), ‘A contribution to the empirics of economic growth’, *The Quarterly Journal of Economics* **107**(2), 407–37.
- Martin, R. (2001), ‘Emu versus the regions? regional convergence and divergence in euroland’, *Journal of Economic Geography* **1**(1), 51–80.
- Mylonidis, N. and Kollias, C. (2010), ‘Dynamic european stock market convergence: Evidence from rolling cointegration analysis in the first euro-decade’, *Journal of Banking and Finance* **34**(9), 2056–2064.
- Nguyen, T. L. H., Tran, T. G. and Le, T. H. M. (2014), ‘The impact of external shocks on small open economies: Evidence from east asian countries’, *International Journal of Economics and Finance* **6**(2), 206–217.
- Ocampo, J. A. (2009), ‘Latin america and the global financial crisis’, *Cambridge Journal of Economics* **33**, 703–724.
- Osterwald-Lenum, M. (1992), ‘A note with quantiles of the asymptotic distribution of the maximum likelihood cointegration rank test statistics’, *Oxford Bulletin of Economics and Statistics* **54**(3), 461–472.
- Pritchett, L. (1997), ‘Divergence, big time’, *Journal of Economic Perspectives* **11**(3), 3–17.
- Pritchett, L. (2000), ‘Understanding patterns of economic growth: Searching for hills among plateaus, mountains, and plains’, *World Bank Economic Review* **14**(2), 221–50.
- Quah, D. (1993), ‘Empirical cross-section dynamics in economic growth’, *European Economic Review* **37**(2–3), 426–434.
- Quah, D. (1996), ‘Twin peaks: Growth and convergence in models of distribution dynamics’, *Economic Journal, Royal Economic Society* **106**(437), 1045–55.
- Quah, D. (1997), ‘Empirics for growth and distribution: Stratification, polarization, and convergence clubs’, *Journal of Economic Growth* **2**(1), 27–59.
- Sanahuja, J. A. (2012), Post-liberal regionalism in south america: The case of unasur, Technical Report RSCAS 2012/05, Robert Schuman Centre for Advanced Studies.
- Solow, R. (1956), ‘A contribution to the theory of economic growth’, *The Quarterly Journal of Economics* **70**(1), 65–94.
- Temple, J. (1999), ‘The new growth evidence’, *Journal of Economic Literature* **37**(1), 112–156.
- Thomakos, D. D. and Papailias, F. (2014), “out of sync”: The breakdown of economic sentiment cycles in the eu’, *Review of International Economics* **22**(1), 131–150.

# Appendix

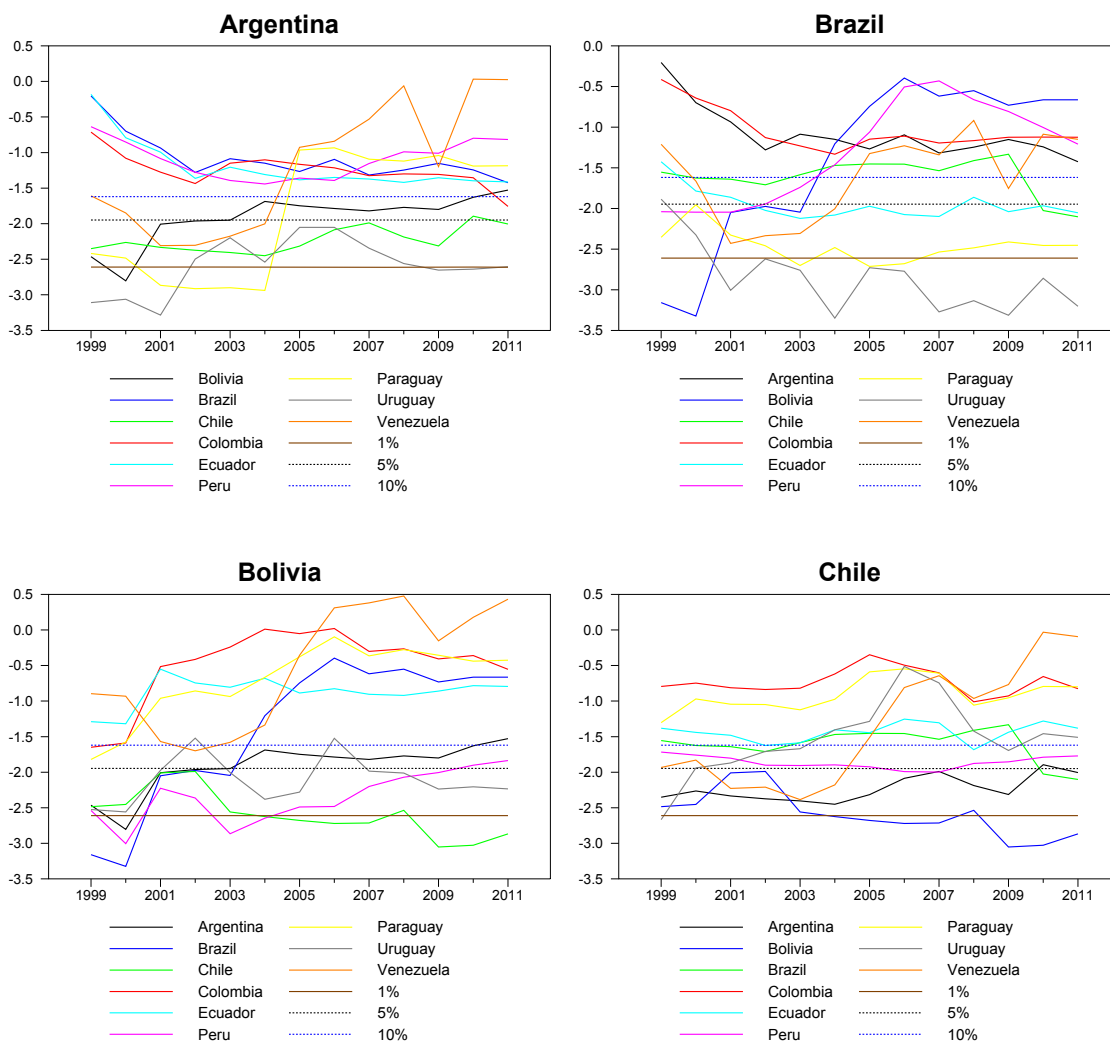


Figure 9: *Rolling cointegration tests: ADF statistics for the residuals of the cointegration regression (49-year fixed length window).*

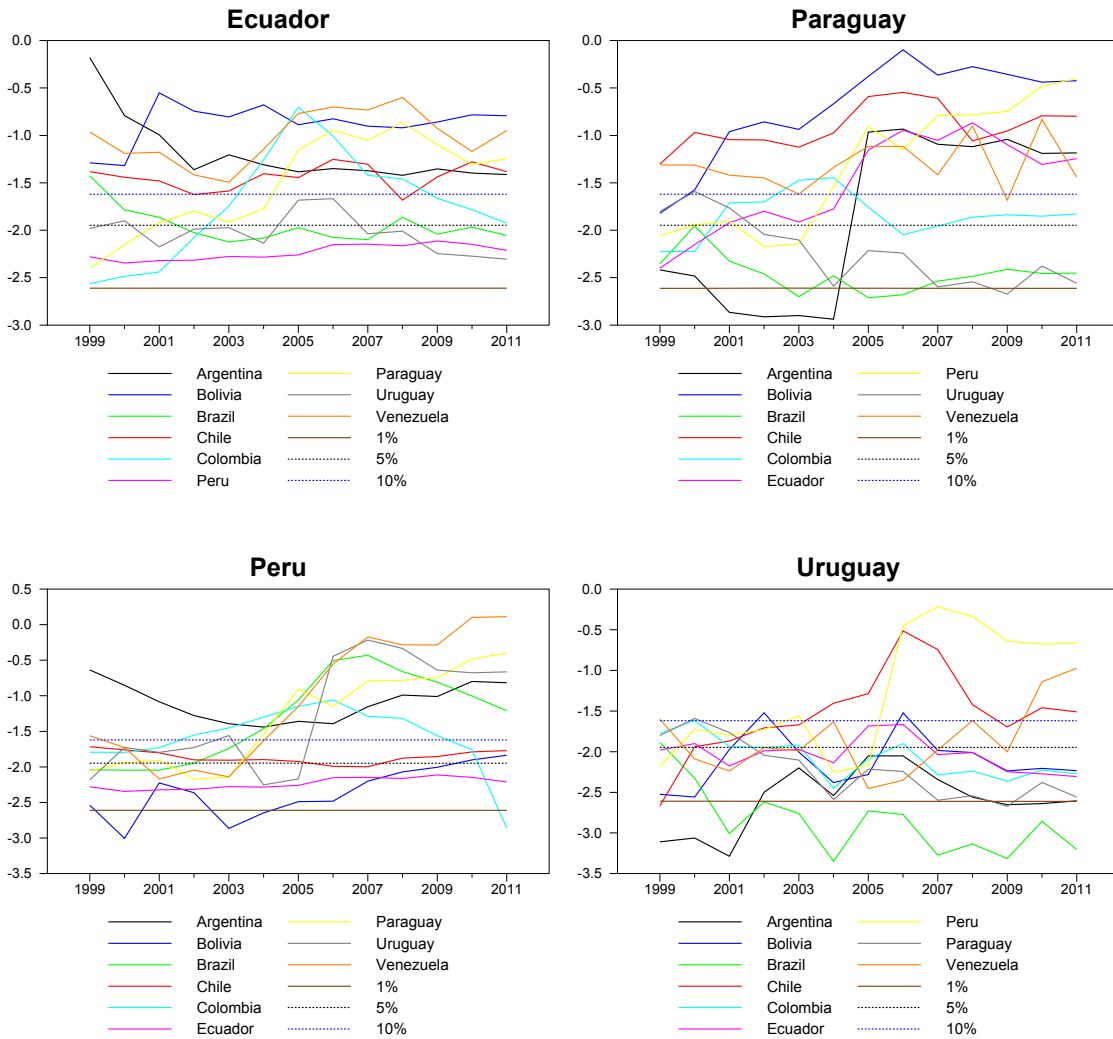


Figure 10: *Rolling cointegration tests: ADF statistics for the residuals of the cointegration regression (49-year fixed length window).*