Convergence in South American countries’ Output

– Preliminary version. Do not quote. –

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Abstract
This paper evaluates convergence in real GDP per-capita of Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Peru, Uruguay, Paraguay and Venezuela for the period 1951-2011. Since 2000, the South American economies have undertaken several regional projects in view of the elimination of socioeconomic inequalities between them for the improvement of their citizens’ living standards. By relying on cointegration techniques and applying Bernard and Durlauf (1995) stochastic definitions of convergence and common trends, this study provides evidence supporting 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
JEL classification: C32, O40, O54

1 Introduction
After a decade of economic instability and recurrent crisis, the South American countries received the 21st century with a new strategy. They decided to bet on regional integration and thus started to look forward towards a common horizon. In September 2000, all the Presidents of the twelve South American independent nations joined together for the first time in history and discussed about strategies of development and progress for the region as a whole. At the end of the day, the ambitious goal of organizing coexistence within a common territory of democracy, peace, mutual cooperation and shared economic and social development was adopted (Brasilia’s Statement). The very same year, the Initiative for the Integration of Regional Infrastructure in South America (IIRSA) was launched and eight years later the Union of South American Nations (UNASUR) was formally created as as an entity with international juridical character.1

The recentness of the UNASUR integration project makes it hard to assess it. However, something must be changing in South America because its countries’ economies appears to be experiencing a turn of its historically unstable growth pattern since 2000. Figure 1 presents some evidence on this, it displays the evolution of both level and growth of Argentina, Bolivia,
Brazil, Chile Colombia, Ecuador, Peru, Paraguay, Uruguay, and Venezuela’s real output per-capita annual series in logs from 1951 to 2011.²

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

Visibly, real output per-capita of most of the countries, except for Venezuela, is smother in 2000s relatively to previous decades. This phenomenon is even more striking considering that the 2000s has not been spared of international commotion, notably the 2007-2009 Global Financial Crisis through which most Latin American countries passed by relatively unharmed (Boonman et al., 2012). Several reasons have been mentioned for explaining such a phenomenon (i.a., improvements in external balance sheets (Ocampo, 2009), development of domestic bond markets (Jara et al., 2009), however, a second fact, revealed by figure 1, lead us to explore deeper. Economic growth of South American countries not only is smother than before but also appears to be synchronized among the region. The combination of these both facts lead us to think about the strategy adopted by South America, regional integration.

As an intent of understanding, the South American integration project could be thought as a set of short-term actions guided by a common long-term aim. In fact, one the main principle driving the UNASUR objective is the reduction of asymmetries between its countries (i.e., elimination of socioeconomic inequalities) in order to improve the life standards of their citizens.³ Certainly, this is a long-run common objective. In view of its objective, UNASUR nations have taken several measures, for instance, 31 infrastructure projects on regional connectivity networks (transport, energy and communications) are been executed, the Bank of the South – created in 2008 – is financing regional development projects with South American countries’ funds, free movement of people within the region is authorized since 2006, among others. These measures can be though as the set of short-term actions. Finally, allow us to restate the aforesaid driving principle as the reduction of the gap between income levels of the UNASUR members and assume that real GDP per-capita (output) is an accurate measure of relative living standards across countries. In such a scenario, some lights could be shed by analyzing the dynamics of the real GDP per-capita series of the South American countries. Particularly, if the region is evolving towards the full attainment of its common goal, the individual steady states of economic growth of each UNASUR economy should be approaching each other in time until converge at some point and merge in a single regional steady state.

²The data is from the Penn World Table 8.0 and corresponds to expenditure-side real GDP at chained PPPs (in mil. 2005US$) series normalized by population.
³Art. 2 of the Constitutive Treaty of the Union of South American Nations (UNASUR)
of growth (i.e., the short run actions are guiding the countries towards a common well-being state in which dissimilarities between citizens’ living standards do not exist).

As state here, the South American regional integration process could be studied by using the econometric tools that have been developed to analyze the convergence (catch-up) hypothesis of growth economics. Particularly, for our purpose, Bernard and Durlauf (1995) stochastic definitions of convergence in output are relied on. Those concepts as well as its pertinence for analyzing the UNASUR will be developed in Section 3. Section 2 briefly introduce short-run evidence on similarities within UNASUR members. Sections 4 discuss the results, and section 5 concludes.

2 Short-run evidence

Empirical evidence suggest that the reactions of the South American Nations economies to external shocks are considerably synchronized in the short-run (e.g., Bonilla B., 2012, Canova, 2005, Gimet, 2007). Such a short-run synchronization is confirmed by a positive evolution of business cycles correlation across countries in the region. Figure 2 displays Argentina, Bolivia, Brazil, Chile Colombia, Ecuador, Peru, Paraguay, Uruguay, and Venezuela’s business cycles recovered by HP-filtering the annual logged real output per-capita series from 1951 to 2011. It results apparent from the graphical representation that the cyclical component of output across countries is highly synchronized during the 2000’s relatively to past decades. Pairwise-correlations of series in Table 1 provides a quantitative measure of this fact. Certainly, the average correlation of business-cycles relatively increased during the decade 2000-2010 across countries – the highest decade-by-decade correlation coefficient corresponds to the 2000-2011 period, 0.609. However, such a decade-by-decade comparison does imply that countries are evolving towards a convergent long-run path – the average cycles-correlation of the whole period (1951-2011) is just 0.268. Whether or not such a short-run behavior translates into long-run convergence is an issue about which the next section intent to shed some lights.

<table>
<thead>
<tr>
<th>Business-Cycles pairwise correlations</th>
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Notes: Table reports 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 is from the Penn World Table 8.1 and covers the period 1951 to 2011.

Table 1: Average pairwise-correlations of the business-cycles.

3 A long-run approach

The convergence (catch-up) hypothesis of the growth economics, which suggest that low income countries grow faster than rich countries so that the former tend to catch-up the later in the long-run (Abramovitz 1986; Baumol, 1986), spawned an enormous literature typically referred

4The convergence hypothesis stands that poorer economies’ per capita incomes will tend to grow at faster rates than richer economies. As a result, all economies should eventually converge in terms of per capita income (Barro and i Martin, 2004).
Figure 2: Business Cycles: 1951-2011. HP-filtered.

to as “convergence literature”. The convergence literature intends to understand the sources of persistent differences in per capita GDP and growth rates across different regions and thus it provides a wide set of tools for studying long-run dependence. The classical techniques are the so-called $\beta$-convergence (Barro and Sala-i-Martin, 1991, 1995; Mankiw et al., 1992) and $\sigma$-convergence (Friedman, 1992; Cannon and Duck, 2000). Both classical approaches base on the estimation of cross-country regressions tied to neoclassical growth models and so they are static methods which limits are well reported (See Durlauf et al., 2005). Several alternative approaches have been proposed, i.a., distribution dynamics (Quah, 1993, 1996 and 1997), state space models (Bulli, 2001; Johnson, 2004), time series approaches (Bernard and Durlauf, 1995 and 1996; Evans, 1998; Hobijn and Franses, 2000), panel data models (Islam, 1995), event study approaches (Pritchett, 2000).

Time series approaches are suitable for analyzing the South American case because they consider both stochastic and dynamic characteristics. In fact, the very nature of an integration process is dynamic and uncertain. The South American countries’ aim of reduction and elimination of asymmetries in life standards among the region’s citizens is a continuing (dynamic) long-run (uncertain/stochastic) process. Bernard and Durlauf (1995) provides a framework to analyze converge in such an environment. The authors develop stochastic definitions of converge and common trends which can be easily tested with cointegration techniques of the time series literature.

3.1 Theoretical approach and empiric tools

Stochastic definitions of convergence and long-run fluctuations of output requires the analyzed individual series to be non-stationary processes. Let $Y_{i,t}$ be the $n \times 1$ vector containing the individual log real GDP per-capita output ($y_{i,t}$) series of the $n$ UNASUR members, and model

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5 (e.g., Barro and Sala-i-Martin, 2004, Durlauf et al., 2005, Durlauf and Quah, 1999, Islam, 2003) for surveys on the “convergence literature”.

6 Only the pioneer papers are mentioned.
\( Y_{i,t} \) as satisfying
\[
a(L)Y_{i,t} = \mu_{i,t} + \epsilon_{i,t}
\]
where \( a(L) \) has a unit root and \( \epsilon_{i,t} \) is a white noise process so that Bernard and Durlauf (1995) definitions can be applied to the South American case.

According to Bernard and Durlauf (1995), for countries \( i \) and \( j \) to converge, the long-run forecast of output differences between them 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 per-capita gap between them will tend to disappear in the long-run.\(^7\) Although the former definition of converge appears to be the “ideal” result of an integration process, it is unlikely that the UNASUR members satisfy such a strict definition. The embryonic stage of the South American regional integration projects lead us to expect a reject of a null hypothesis of convergence in output. Notwithstanding, it does not imply that the region is not involved in a dynamic “process of convergence”. Even if the South American countries do not satisfy convergence definitions A.1. and A.2, they may still be evolving towards a common long-run objective – convergence in living standards. If it is the case, their individual output paths must respond to the same long-run driving process, i.e. South American countries must have common stochastic trends in output. Bernard and Durlauf (1995) definitions of common stochastic trends in output give us the possibility of test this option.

Table (2) presents Bernard and Durlauf (1995) definitions of converge and common trends in output as well as its empirical testable analogous. Those definitions and test will be applied to the South American case in order to recover some evidence on the current integration status of the region.

### 3.2 Econometric Approach and Data

#### Data

The data employed in the present empirical exercise are annual log real GDP per-capita in 2005 PPP-adjusted dollars for 10 of the 12 UNASUR members. The included countries are Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Paraguay, Peru, Uruguay and Venezuela.\(^8\) The series covers the period from 1950 to 2011 and are taken from the Penn Word Table 8.0.\(^9\)

#### Empirical procedure

The tests of convergence and common trends will follow the procedures developed by Engle and Granger (1987) and Johansen (1988). The presence of unit roots in individual output series will rely on the traditional Augmented Dickey-Fuller (ADF) test.

The analysis will be held in two stages. In a first part, bivariate tests of convergence and common trends of all 45 possible country pairings for the 10 included UNASUR countries are performed in order to shed some lights about sub-grouping alternatives within the region. Second, multivariate tests will provide evidence on the main question of interest, converge of South American countries. In both stages, a null hypothesis of no convergence is tested, if that null cannot be rejected, the number of common trends in output is looked for.

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\(^7\)Every reference to output per-capita is to log real GDP per capita which is assumed to be a comparable measure of life standards across countries.

\(^8\)Suriname and Guyana are not included because of data availability.

\(^9\)The Penn Word Table 8.0 provides data on real GDP in 2005 PPP-adjusted dollars and population, the rest is a matter of data convenient transformations.
Definition

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:

\[
\lim_{k \to \infty} E(y_{i,t+k} - y_{j,t+k} \mid I_t) = 0
\]

Definition equivalent

Countries i and j converge if their output series are cointegrated with cointegrating vector [1,-1]

A.2. Convergence in multivariate output
Countries p = 1,...,n converge if the long-term forecasts of output for all countries are equal at a fixed time t:

\[
\lim_{k \to \infty} E(y_{1,t+k} - y_{p,t+k} \mid I_t) = 0 \quad \forall p \neq 1
\]

In order for the individual output series of all p countries to converge, there must exist p − 1 cointegrating relations of the form [1,-1]. Or, the output deviations from benchmark country \( (y_{1,t+k} - y_{p,t+k}) \) must be a zero-mean stationary process.

B.1. Common trends in output
Countries i and j contain a common trend if the long-term forecasts of output are proportional at a fixed time t:

\[
\lim_{k \to \infty} E(y_{i,t+k} - \alpha y_{j,t+k} \mid I_t) = 0
\]

Countries i and j have a common trend if their output series are cointegrated with cointegrating vector \[1,-\alpha\]

B.2. Common trends in multivariate output
Countries p = 1,...,n contain a single common trend if the long-term forecasts of output are proportional at a fixed time t, let \( \tilde{y}_t = [y_{2,t}, y_{3,t}, ..., y_{p,t}] \):

\[
\lim_{k \to \infty} E(y_{1,t+k} - \alpha y_{\tilde{y}_t+k} \mid I_t) = 0
\]

All p countries share a single common stochastic trend if there exist just one cointegrating relation between them.

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

The adopted notations is as follows. \( y_{i,t} \) denote the output level of country and \( Y_t \) the \( n \times 1 \) vector of individual output levels. \( D y_{i,t} \) is the deviation of output in country i from output in a benchmark country, \( D y_{i,t} = y_{1,t} - y_{i,t} \). The operator \( \Delta \) indicates the first difference of series.

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

\[
\Delta Y_t = \mu + C(L)e_t
\]

Engle and Granger (1987) demonstrated 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) consist to estimate the regression

\[
y_{1,t} = \alpha_0 + \alpha_1 y_{2,t} + ... + \alpha_{n-1} y_{n,t} + \varepsilon_t^{10}
\]

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

\[
\Delta \varepsilon_t = -\theta \varepsilon_{t-1} + B(L) \Delta \varepsilon_t + \gamma_t^{11}
\]

\( ^{10} \)This is so-called cointegrating regression because it represents the long-run relationship between variables.

\( ^{11} \)This specification allows for non-white noise \( \varepsilon_t \) residuals.
If a cointegration relation exist between series, the null that \( \theta = 0 \) must be rejected. As well know, a major drawback of this test is the relative low power against other alternatives, especially in multivariate contexts.\(^{12}\) That is why the Johansen (1988) technique is also applied.

Johansen’s (1988) test estimates the rank of the cointegrating matrix \( \Pi \) from a finite-vector autoregressive representation of the output vector of the form

\[
\Delta Y_t = \Gamma(L) \Delta Y_t + \Pi Y_{t-1} + \Phi D_t + \varepsilon_t
\]  

(4)

where

\[
\Gamma_i = -(A_{i+1} + ... - A_k), \quad (i = 1, ..., k - 1)
\]

and

\[
\Pi = -(I - A_1 - ... - A_k)
\]

\( \Gamma(L) \) captures the short-run dynamics while the long-run relationships of the individual series are captured by \( \Pi \). \( D_t \) contains deterministic terms. As cointegration refers to long-run relationships, Johansen (1988) test is based on the rank of \( \Pi \). If \( \Pi \) has reduced rank, it can be written as

\[
\Pi = \alpha \beta'
\]  

(5)

with \( \alpha \) and \( \beta \), \( p \times r \) matrices of rank \( r \leq p \). \( \beta \) is the matrix of 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.\(^{13}\) Although \( \beta \) is not uniquely determined – a different \( \alpha \) satisfying relation (5) will produce a different \( \beta \), for any normalization chosen, 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) test explodes 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 \( \hat{\lambda}_1 > \hat{\lambda}_2 > ... > \hat{\lambda}_p \) of the matrix \( \Pi \). The statistics are

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

(6)

If \( \hat{\Pi} \) is of full rank, \( p \), none 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 for 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 hypothesis are that the rank is \( r \) and \( r + 1 \) respectively.

**Bivariate**

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

\[
y_{i,t} = \epsilon_{ij} + \alpha_{ij} y_{j,t} + \varepsilon_{ij,t}
\]  

(7)

where \( y_{i,t} \) and \( y_{i,t} \) are \( I(1) \). AFD statistics are computed next 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 \( j \).

\(^{12}\)When \( n > 2 \), there could exist more than one cointegrating relation, possibility not accounted for Engle and Granger’s (1987) method.

\(^{13}\)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 the long-run output levels are not related across countries.
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 the countries $i$ and $j$ will be then proved to satisfy the converge hypothesis (A.1. Definition in table 2), i.e., standards of living in both countries will be similar.\(^{14}\)

**Multivariate**

Multivariate convergence and common trends for the 10 UNASUR countries is tested using Johansen’s (1988) procedure as described previously. The asymptotic null distribution of LR trace and maximum likelihood statistics (6) of Johansen test is not chi-square but instead is a multivariate version of the Dickey-Fuller unit root distribution which depends on the dimension $p-r$ and the specification of the deterministic terms $\Phi_D t$ in the estimated system (4). A correct specification is therefore crucial for 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 exhibit 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), V. $\mu t = \mu_0 + \mu_1 t$ (unrestricted constant and trend). Critical values for LR trace and maximum likelihood statistics’ distribution are tabulated in Osterwald-Lenum (1992) for the five trend cases.

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

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

the series in $Y_t$ are $I(1)$ without drift and the cointegrating relations $\beta' Y_{t-1}$ have non-zero means $\rho_0$.\(^{15}\)

Multivariate convergence is tested using Engle and Granger’s (1987) technique. If all $Dy_{i,t} = y_{1,t} - y_{i,t}$ are stationary processes, the UNASUR will evidence to be a convergent region. For detecting common stochastic trends within UNASUR, Johansen’s (1988) methodology will be employed.

**4 Results**

First of all, the presence of stochastic trends in each of the 10 output series is tested. Figure 3 displays the output series in level and growth and Table 3 reports Augmented Dickey-Fuller (ADF) statistics. A graphical inspection of individual output series suggest that series are $I(1)$. The null hypothesis of a unit root in output cannot be rejected for none of the 10 output series in levels. A similar exercise confirms the rejection of the null hypothesis of a unit root for the correspondent first differences. The 10 individual output series are thus $I(1)$ processes.

\(^{14}\)Bernard and Durlauf’s (1995) definitions of convergence (Definitions A.1 and A.2 in table 2) implies that if the output series are trend-stationary, the time trends must be the same between countries $i$ and $j$. This option is accounted by evaluating convergence as the absence of unit roots in $y_{i,t} - y_{j,t}$.

\(^{15}\)The choice is justified for graphical inspection of $I(1)$ series and pairwise results of cointegration. As a robustness check all 5 options were estimated and compared using BIC information criteria, option 2) is selected according to this.
Figure 3: Log per capita output 10 UNASUR countries. Level and Growth series. 1951-2011
In testing for convergence and common trends, two stages are defined. As preliminary evidence, pairwise tests are performed for all 45 possible country pairings. Such an evidence is used to perform test for separate groupings of countries.

4.1 Pairwise Analysis

Table 4 and 5 present results for pairwise convergence and cointegration, respectively. The null of no convergence is initially tested for all pairs. If that null cannot reject, the presence of common trends in output is then tested. No evidence of convergence is found (Table 4). None of the pairwise output gaps $y_{i,t} - y_{j,t}$ appears to be stationary processes, i.e., differences in pairwise living standards within the UNASUR are not temporary but permanent. Because of the infancy of the South American integration project, the no-convergence was expected. However, this results cannot be interpreted as a negative assessment of the achievement of the South American common goal.

Pairwise cointegration is tested next. The null of no cointegration is rejected for 17 of the 45 pairs of countries. Output of those 17 partner nations appears to be driving for a common process. These results give support to the idea that there are common elements in output growth across countries.

At this stage, it is worth to remember that UNASUR includes two ancient blocs: the Common South Market (MERCOSUR) and the Andean Community of Nations (CAN). Before the UNASUR was created, the MERCOSUR members were Argentina, Brazil, Paraguay and Uruguay and the CAN members were Bolivia, Colombia, Ecuador and Peru.\(^\text{16}\) Because of the actual South American integration project, the Andean Community of Nations is involved in a dissolution process and the Common South Market is accessing the rest of UNASUR members. Once the process will be completed, the all South American region will form a common market. Such an historical relationships are expected to be reflected in results.

Evidence of cointegration is found for 4 of 6 possible country pairings for the four ancient MERCOSUR members. For the CAN, only 3 of 6 possible country pairings appears to be

\(^\text{16}\)Venezuela were also a CAN members, however, its has abandoned and rejoined the group because of political differences with the members. Moreover, Venezuela is the only non-funding country. That is why Venezuela is not accounted as CAN member for the purposes of the present study.
<table>
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Notes: The table reports ADF statistics for testing the null that $\varepsilon_{ij,t} = y_{i,t} - y_{j,t}$ is not a stationary-process. Estimated equations, which lag structure is chosen according to BIC criterion, are:

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

Table 4: Pairwise Convergence Tests for 10 UNASUR countries: 1951-2011

<table>
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<td>-0.619</td>
<td>-2.425*</td>
<td>-1.462</td>
<td>-1.389</td>
<td>-1.106</td>
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<td>-1.386</td>
<td>-1.584</td>
<td>-0.405</td>
<td>-0.908</td>
<td>-2.088*</td>
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<tr>
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<td>-3.385**</td>
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<td>-1.749</td>
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<tr>
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<td>-2.088*</td>
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<td>-2.088*</td>
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<tr>
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<td>VE</td>
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<td>-0.382</td>
<td>-0.708</td>
<td>-1.047</td>
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</table>

Notes: The table reports ADF statistics for testing the null that $\varepsilon_{ij,t}$ is not a stationary-process. One (*) and two asterisks (**) denote significant at 5% and 1% respectively. The estimated equations are (lag structure for $B(L)$ selected according to BIC criterion):

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

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

Table 5: Pairwise Cointegration Tests for 10 UNASUR countries: 1951-2011
cointegrated. Surprisingly, Colombia’s output has common stochastic trends with none of the other CAN members (See Table 5). Another interesting results, even if expected, is the nonexistent evidence of common stochastic trend between Venezuela and the other South American countries. As illustrated in figure 3, Venezuela’s output evolution differs significantly relatively to the other analyzed countries.

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</tbody>
</table>

3 5 3 4 1 5 3 4 6 0

Notes: The table summarizes pairwise cointegration evidence. X in \( x_{ij} \) denotes that the output of country \( i \) and \( j \) passed the cointegration test.

Table 6: Pairwise Cointegration

Pairwise evidence is used to define separate groupings of countries to be analyzed in addition to the whole sample of 10. Table 6 summarizes the number significant cointegrating relations, X in \( x_{ij} \) denotes that the output of country \( i \) and \( j \) are cointegrated. As aforesaid, Venezuela has no common driving process with the other countries. On the contrary, Uruguay ranks as the nation sharing the greater number of common stochastic trends (Uruguay’s output has common driving processes with 6 of the 9 other countries).

In base of the pairwise evidence, six separated grouping are defined and used in testing for 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 ancient MERCOSUR members, e) the four ancient CAN members, and finally, f) MERCOSUR, CAN, Chile and Venezuela are tested together. The output series of MERCOSUR and CAN are the aggregation of the members’ output in each group. The multivariate convergence is only tested for the whole group of ten.

4.2 Multivariate

Convergence in multivariate output as determined by Definition A.2 in Table 2, requires the existence of \( p - 1 \) cointegrating relations of the form \([1,-1]\), i.e. the output deviations from benchmark country \((Dy_{i,t} = y_{t} - y_{i,t})\) must be a zero-mean stationary process. Accordingly, output deviation are constructed with Uruguay as benchmark. Uruguay is chosen as benchmark for being the country with the greater number of common stochastic trends with the other countries.\(^{17}\) Pairwise previous evidence lead us to expect the no-rejection of the broad null of no multivariate convergence, such an expectation is confirmed by results. Figure 4 illustrates the dynamic evolution of the output deviations, no-signals of stationary are reported. Augmented

\(^{17}\)The results holds for any other choice of benchmark country.
Dickey-Fuller statistics presented in Table 7 confirms the no-convergence expectations.\(^{18}\)

![Output Gap: 1951-2011](image)

**Figure 4:** Output deviations from Uruguay

\[
\begin{array}{c|c}
  & Dy_{i,t} \\
  \hline
  Argentina & -1.82929 \\
  Bolivia & -2.55371 \\
  Brazil & -1.01526 \\
  Chile & -1.96794 \\
  Colombia & -1.51047 \\
  Ecuador & -2.01791 \\
  Peru & -2.61093 \\
  Paraguay & -1.22003 \\
  Venezuela & -2.14386 \\
\end{array}
\]

**Notes:** Augmented Dickey-Fuller (ADF) statistics, lag length chosen by the BIC criterion. \(Dy_{i,t} = y_{ur,t} - y_{i,t}\) denotes output deviations. Uruguay as benchmark country.

**Table 7:** Multivariate convergence. 10 UNASUR countries.

The presence of multivariate common trends is tested next using Johansen methods. The results from the Johansen trace and maximum eigenvalue statistics are presented in Table 8 for each of the six subsets of countries defined previously and Figure 5 illustrates output series by subgroup. The lag structure was chosen using the BIC criterion, according to which a lag length of 1 describes properly the dynamics of the system.

Taking all the 10 countries as a group, for a 5% of confidence, the test reject the null hypothesis that there are more than eight unit roots but it cannot reject the null that there are more than seven unit roots. This result suggests the existence of eight common stochastic trends in output for the 10 countries, i.e. two cointegrating relationships as the long-run impact matrix \(\Pi\) has two non-zero eigenvalues. Although common long-run processes driving output in the South American region appears to exist, the number of processes is still relatively high for achieving convergence in living standards.

\(^{18}\)Several authors have tested the convergence hypothesis for the European countries concluding that the output of European countries is not convergent (Reference required). The integration project of Europe is much more advanced than the South American one. Therefore, the no-rejection of the null of no convergence in here should not be taken as a negative evaluation of the project.
Figure 5: Subsets of UNASUR countries
Results do not significantly change when Venezuela is excluded of the sample, Johansen’s test supports the existence of seven common trends for the sub-sample of nine countries. A similar result (not shown in Table 8) is obtained when excluding Colombia of 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, suggest that Colombia and Venezuela by its own do not really make a difference for the common integration goal. However, the both countries do make a difference.

Switching to the ancient MERCOSUR and CAN members as subgroups, similar evidence is found for each one of the subsets. 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 appears to be guiding the output in each separate sub-grouping of four members. Compared to the whole sample of ten, the number of long-run processes driving output in the selected sub-samples is larger. This supports the hypothesis that separate UNASUR members do not perform as well as they do jointly. The very same is found for the special subset formed by MERCOSUR, CAN, Chile and Venezuela.

The large number of common trends revealed by Johansen’s multivariate test supports the conclusion that output series in South America do not converge. If any sign of converge would be present, the test statistics should confirm the existence of one single common trend for each group of countries.

## 5 Conclusions

A common objective drives South American countries’ actions since they has committed to be part of a recent integration process, reduction and elimination of disparities among its citizens’ living standards. Such an ambitious aim could be redefined as the achievement of convergence in real per-capita output series of the individual countries in the region. In order to shed some lights about the current state of convergence of South American region, Bernard and Durlauf (1995) definitions of convergence and common stochastic trends are used to perform unit roots
and cointegration test for ten of the twelve members of the Union of South American Nations: Argentina, Bolivia, Chile, Colombia, Ecuador, Peru, Paraguay, Uruguay, Venezuela. Log real per-capita GDP is assumed to be a proxy measure of the living standards across countries. Pairwise and multivariate evidence reveals the existence of a relatively large number of common long-run trends driving output in South America and rejects the convergence hypothesis for the zone. Although this evidence suggest that UNASUR is very far from achieving its objective, the existence of common long-run processes in output suggest that economic growth of the individual UNASUR members do not respond exclusively to idiosyncratic, country-specific factors but also to its common objective.

References


Bonilla B., A. (2012). External vulnerabilities and economic integration. is the union of south american nations a promising project? Working Papers 1238, GATE LSE CNRS.


