Iran. Econ. Rev. Vol. 20, No. 2, 2016. pp. 141-162

Income Convergence toward USA: New Evidences for Latin and South American Countries

Omid Ranjbar*[1]
Tsangyao Chang[2]
Chien-Chiang Lee[3]

Received: 2016/05/21 Accepted: 2016/06/06

Abstract
In this paper we test two versions of convergence hypothesis namely deterministic or conditional convergence and stochastic or catching up hypothesis using Carrion-i-Silvestre et al. (2005) stationary test. The results show Latin and South American countries (LSA) catching up process toward the USA failed in 1980s and somewhat in 1990s. But in 2000s most of them could lie in convergence path. Dispersion of break dates show that structural breaks in LSA convergence were affected by trade policies, terms of trade shocks and also war. For example, terms of trade shocks due to volatility of primary goods prices such as sugar, copper, cotton, petroleum oil, coffee, bauxite, aluminum, and rice affected the convergence process in LSA countries.
Keywords: Income Convergence, Catching up, Stationary Test, Structural Breaks, Latin and South America.
JEL Classification: O_{41}, C_{32}.

1. Introduction
There is a large body of studies that examines the issue of income convergence employing a variety of methodologies, but there is no consensus among analysts due to the inconclusive results therein (Durlauf et al, 2006). Most of the studies on this issue were done in developed and developing economies, such as among OECD countries, European economies or Asian economies. However, very few studies are done extensively in Latin American economies. Over the past three decades, the economic performance of Latin America was lackluster. However, Latin American countries have been implementing

1. Department of Economics, Allameh-Tabataba'i University, Tehran, Iran.
2. Department of Finance, Feng Chia University, Taichung, Taiwan. (tychang@fcu.edu.tw).
3. Department of Finance, National Sun Yat-sen University, Kaohsiung, Taiwan. (cclee@cm.nsysu.edu.tw).

structural and macroeconomic adjustment programs designed to improve the economic growth of these economies (Divino et al., 2009). As noted by de Medeiros (2011), the Latin American countries experienced two major institutional and structural transitions, which affect their strategies and patterns for economic development in the last century. First, in the 1930s, the pattern based on exports of natural resources is replaced a new growth strategy based on industrialization. In the period 1950-1980, following the pace industrial output growth, the Latin American countries' GDP per capita is steadily increasing.

Second, in the 1990s, a renewed export strategy focused on exports of resource-intensive goods replaced the previous strategy. Thus, it is important that we must take structural breaks into account when examining the convergence hypothesis in the Latin America.

This study investigates the income convergence hypothesis among 34 Latin and South American countries relative to United States over the 1969 to 2011. Theoretical models of growth have important implications for the stochastic/convergent behavior of real income per capita differentials between countries. The neoclassical Solow-Swan model predicts that countries with identical determinants of steady state levels of income would converge in the long run. Furthermore, the New Growth Theory model predicts that income would diverge because the non-convexities swayed by physical or human capital. Empirical tests on income convergence have been carried out by Campbell & Mankiw (1989), Carlino & Mills (1993), Bernard & Durlauf (1995), Fleissing & Strauss (2001), Charles et al. (2011), and, they do not find evidence of convergence. Recently, Pesaran (2007) also presents a pair-wise test and rejects the existence of convergence in output levels. However, Loewy & Papell (1996), Li & Papell (1999), Strazicich et al., 2004, De Siano & D'Uva (2006), Dawson & Sen (2007), Jr Galvao & Gomes (2007) who find more supportive evidences in favor of income convergence in different contexts.

Stationarity is a concept that is closely related to the concept of convergence. Time series tests of convergence typically test for stationarity or for the presence of a unit root (Durlauf et al., 2009). It is well-known that the unit-root test is powerless if the true data generating process of a series exhibits structural breaks (Perron, 1989). Im et al. (2005), however, address this concern about panel data and extend the univariate LM unit-root tests, as proposed by Lee & Strazicich (2003), to the panel data framework. We must bear in mind that these researchers' analyses are restricted, and that the empirical size of their tests is not affected by misspecification errors with respect to the dates of any breaks. The main shortcoming is that they apply the LM test statistic regardless of there being up to two structural breaks. To consider potential structural breaks, we apply the panel data stationarity test developed by Carrion-i-Silvestre et al. (2005, CBL hereafter).

Previous empirical work on income convergence typically neglects possible multiple structural changes in panel data framework, thereby controlling for cross-sectional dependence through bootstrap methods. There are three important factors when performing tests that allow for structural breaks. The first factor is that structural breaks may be associated with atypical events (domestic and international, integration, regulations, and globalization). The second aspect is that considering structural breaks allows us to obtain more detailed information on convergence hypothesis. Third and finally, the economic system's instability may in fact be reflected in the parameters of the estimated models that, when used for inference or forecasting, can induce misleading results.

This paper contributes to the debate regarding the validity of the empirical basis of income convergence hypothesis in several respects. First, no study has applied a panel data framework with multiple structural breaks to analyze deterministic convergence (conditional convergence) and stochastic convergence (catching up hypothesis) in Latin and Southern America, a task that we set as our object in this paper[1]. At the same time, these tests can explain whether there are different income convergence effects in countries at the same developmental level. However, stochastic convergence is a necessary but not sufficient condition for conditional convergence.

Thus, we supplement the tests for stochastic convergence with additional β -convergence sigma convergence) test to determine whether conditional convergence is occurring[2].

Second, the reversal of the null and alternative hypotheses is very appealing for the CBL (2005) test, because for most of the panel unit root tests the rejection of the unit root null implies that only some (but not all) countries are stationary. If the null is not rejected for the CBL test, then we find that all of the series in the panel are stationary and thus all support stochastic convergence.

---

1. Convergence implies that countries with relatively low initial levels of income will grow faster than countries with relative high initial levels of income in order to catch-up (Strazicich et al., 2004). Stochastic convergence is the case where the difference in per capita real income between two economies is related to a trend stationary process (Quah, 1993). On other hand, deterministic convergence is associated to a constant mean stationary process. Thus, deterministic convergence implies stochastic convergence, but not the other way around.
2. "β -convergence" occurs when there is a negative relationship between the average growth rate of the relative income and its initial log per-capita level. On the other hand, "sigma convergence" is accepted when the standard deviation of the relative income decreases over time (Barro & Sala-i-Martin, 1992).

Third, the CBL method enables us to determine individual fixed effects and/or individual specific time trends. It also permits us to consider multiple structural breaks positioned on different unknown dates in addition to a different number of breaks for each individual. As such, allowing for breaks can potentially strengthen our results by more correctly specifying the model.

Fourth and finally, we allow for more general forms of cross-sectional correlation than previous studies through the conventional cross-sectional demeaning of the data, which assumes that a common factor affects all units with the same intensity. Carrion-i-Silvestre and German-Soto (2009) also indicate that the lack of consideration of the cross-sectional dependence might bias the analysis to conclude in favor of the stationarity of the panel data even in the case where it is non-stationary. It is important to note that the panel stationarity test controls non-parametrically for serial correlation in the error through the estimation of the long-run variance via kernels. We employ the bootstrap distribution tailored to the error structure of panel data in order to accommodate general forms of cross-dependence.

The plan of this paper is organized as follows. Section 2 presents the data used in our study and outlines the methodology we employ and then Section 3 discusses the empirical findings. Finally, Section 4 reviews the conclusions we draw.

2. Data Description and Methodology

2.1 Data Description

We collect annual per capita real GDP (2005 = 100) for 34 Latin and South American countries (LSA) (i.e. Antigua and Barbuda, Argentina, Bahamas, Barbados, Belize, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, Ecuador, El Salvador, Grenada, Guatemala, Guyana, Haiti, Honduras, Jamaica and Dependencies, Mexico, Nicaragua, Panama, Paraguay, Peru, Puerto Rico, St Kitts and Nevis, St Lucia, St Vincent and the Grenadines, Suriname, Trinidad and Tobago, Uruguay, and Venezuela) and the USA as base country, over the 1969 to 2011 period. The source of the data is the World Economic Outlook Database.

Table 1 provide average real per capita GDP (in logs) and average real GDP per capita growth rate in any decade and for the period 1969-2011. If we look at the dynamics of the per capita real GDP datasets over the past four decades 1970’s, 1980’s, 1990’s and 2000’s, indicating that St Vincent and the Grenadines, Suriname, Nicaragua, Paraguay, Guyana, Haiti, Honduras, Guatemala, El Salvador, and Bolivia had lowest per capita real GDP and Trinidad and Tobago, Uruguay, Venezuela, Puerto Rico, St Kitts and Nevis, Mexico, Argentina, Bahamas, Barbados, and Antigua and Barbuda had highest per capita real GDP over most of decades among Latin and South American countries. On the other hand, dynamics of per capita real GDP growth rate over four past decades show countries such as Venezuela, Haiti, Nicaragua, and Bahamas experienced lowest growth rate over most of decades and were growth disaster among Latin and South American countries. In contrast, countries such as St Vincent and the Grenadines, Chile, and Dominican Republic experienced highest growth rate over most of decades. Among LSA countries that exist in our samples, some countries show interesting growth performance. For example, Argentina was one of the countries that experienced lowest growth rate over two decades 1970s and 1980s. It experienced a negative growth rate in 1980s.

Then it improve its growth performance over the 1990-2011 period and experienced a positive growth rate over two decades 1990s and 2000s and lied in group with highest growth rate. Chile, Bahamas, and Dominica were three of 34 LSA countries that experienced lowest growth rate in decades 1970s. But in 1980s that most of LSA countries experienced negative or low growth rate, they could reach to high growth rate. After 1980s, Chile could continue its good growth performance and experienced high growth rates and lied in group with highest growth rate but Bahamas and Dominica could not continue the good growth performance and even in later decades lied in lowest growth rate group.

Table 1: Average of Real GDP per capita and its Growth Rate in any Decade

Country/ year	AvRI 70	GRI 70	AvRI 80	GRI 80	AvRI 90	GRI 90	AvRI 2000	GRI 2000	AvRI 70-2001	GY 70-2011
Antigua and Barbuda	3135.73	4.25	5734.93	6.98	8604.38	1.70	10705.47	1.14	7110.78	3.43
Argentina	4064.43	1.09	3813.26	-2.95	4154.30	3.79	4982.37	3.45	4277.09	1.27
Bahamas	13616.52	0.24	17650.00	1.98	18401.10	0.67	20917.19	-0.74	17789.35	0.30
Barbados	7664.86	2.01	9070.45	1.45	9745.61	1.01	10606.32	-0.25	9272.76	1.13
Belize	1476.20	4.32	1995.86	1.40	2922.42	2.41	3870.90	1.31	2594.81	2.90
Bolivia	1003.39	2.15	895.53	-2.22	933.46	1.62	1087.82	1.97	983.31	0.76
Brazil	3271.11	5.53	3993.87	0.09	4135.04	0.77	4825.59	2.23	4050.17	2.16
Chile	2807.20	0.56	3229.94	2.03	5266.00	4.94	7442.38	2.89	4772.37	2.65
Colombia	2113.79	3.34	2555.52	1.06	3049.90	0.75	3659.13	2.80	2856.76	2.15
Costa Rica	2982.93	3.08	3047.80	-0.44	3666.94	2.92	4880.85	2.51	3674.09	1.96
Cuba	2579.22	3.85	3893.25	3.94	3040.90	-2.77	4376.26	4.67	3481.87	2.32
Dominica	1687.17	0.47	2483.60	5.71	3776.27	2.64	4193.03	0.41	3054.15	2.52
Dominican Republic	1844.31	4.25	2273.55	1.03	2667.23	4.14	4025.14	3.66	2730.11	3.34
Ecuador	2078.79	4.12	2343.39	-0.68	2397.68	-0.24	2725.09	2.69	2383.74	1.56
El Salvador	2470.70	1.39	1923.33	-2.01	2276.00	3.38	2906.42	1.67	2414.93	0.78
Grenada	1653.55	4.09	2501.19	4.92	3534.22	2.29	4207.77	-0.72	2994.53	2.58
Guatemala	1853.90	3.37	1872.20	-2.40	1901.56	1.91	2279.54	1.25	1980.29	1.11
Guyana	887.09	0.65	765.81	-3.62	868.62	5.34	1110.08	2.22	915.58	1.05
Haiti	796.64	1.96	800.37	-2.55	606.19	-2.28	529.95	-0.60	677.67	-0.79

Country/ year	AvRI 70	GRI 70	AvRI 80	GRI 80	AvRI 90	GRI 90	AvRI 2000	GRI 2000	AvRI 70-2001	GY 70-2011
Honduras	997.63	3.86	1076.40	-0.83	1079.10	0.13	1160.81	1.13	1076.76	0.91
Jamaica and Dependencies	3609.94	-1.62	3073.43	1.95	3979.59	0.77	4071.88	0.42	3692.84	0.51
Mexico	5289.91	3.58	6538.96	-0.77	6809.87	1.42	8031.41	0.81	6678.93	1.55
Nicaragua	1669.67	-3.11	1106.79	-3.95	771.25	0.25	929.49	1.58	1122.62	-1.13
Panama	3194.09	1.88	3482.99	-1.36	3786.94	3.26	5361.76	4.59	3995.14	2.23
Paraguay	891.98	5.41	1282.32	-0.10	1330.18	-0.27	1324.55	2.44	1201.13	1.92
Peru	2664.67	0.91	2595.04	-2.52	2259.99	2.17	3116.99	4.51	2675.45	1.24
Puerto Rico	9497.58	2.79	11500.07	2.50	16047.61	3.37	20520.79	0.06	14521.29	2.19
St Kitts and Nevis	2238.01	6.43	4025.09	5.99	6763.78	3.41	8842.10	0.53	5533.28	4.05
St Lucia	2243.38	1.28	2700.78	4.04	4583.82	1.46	4987.99	0.77	3656.64	2.18
St Vincent and the Grenadines	1433.92	1.54	1938.08	5.02	2838.69	3.16	4337.03	2.89	2682.70	3.27
Suriname	2116.83	2.63	1935.60	-2.20	1982.32	1.57	2458.68	2.52	2131.92	1.03
Trinidad and Tobago	7075.16	3.32	7886.08	-4.19	6895.61	2.81	12998.61	5.39	8849.96	2.29
Uruguay	3463.79	2.32	3793.73	-0.58	4805.54	3.50	5772.27	3.08	4490.64	2.03
Venezuela	6885.42	0.25	5767.65	-2.51	5703.83	-0.10	5884.33	1.45	6064.39	-0.07

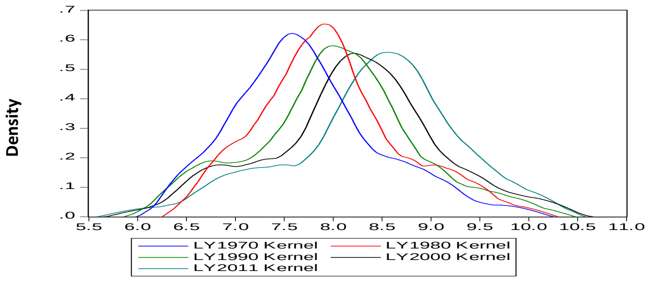
avRI70: Average GDP per capita over decade 1970_s
GRI70: Average GDP per capita growth rate over decade 1970_s
avRI80: Average GDP per capita over decade 1980_s
GRI80: Average GDP per capita growth rate over decade 1980_s
avRI90: Average GDP per capita over decade 1990_s
GRI90: Average GDP per capita growth rate over decade 1990_s
avRI2000: Average GDP per capita over decade 20000_s
GRI2000: Average GDP per capita growth rate over decade 2000_s
avRI70-2001: Average GDP per capita over 1969- 2011 period
GY70-2011: Average GDP per capita growth rate over 1969- 2011 period

2.2 Sigma Convergence and β Convergence

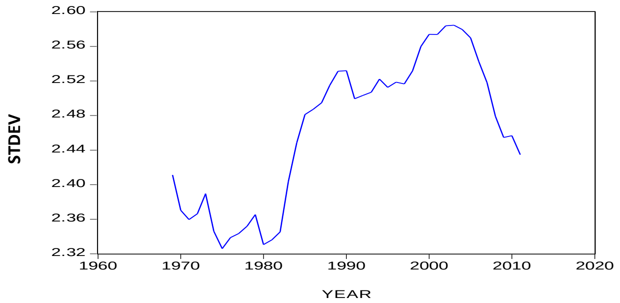
In the Panel a of Figure 1 we present kernel density of per capita real GDP of LSA countries for five years 1970, 1980, 1990, 2000, and 2011. Distribution of GDP per capita over these years shows that cross-sectional income distribution among LSA countries move toward twin peaks. Also dynamics dispersion of LSA countries real GDP per capita (in logs) around USA real GDP per capita (cross-section standard deviation around USA) in panel B of Figure 1 show that dispersion of LSA countries per capita GDP around USA decreased over decade 1970s (sigma convergence), But from 1980 until mid-2000s it increased non monotonically (sigma divergence) and after mid-2000s it decreased.

Fig. 1: Distribution of GDP per capita in Latin America and Sigma Convergence

Panel A: Kernel density for GDP per capita (in logs) of initial year of any decade (1970, 1980, 1990, 2000, and 2011)



Panel B: Cross-section standard deviation of Latin America real GDP per capita around USA (Sigma convergence)



1) LY1970 Kernel, LY1980 Kernel, LY1990 Kernel, LY2000, and LY2011 Kernel are Kernel distribution of per capita real GDP (in logs) for five years 1970, 1980, 1990, 2000, and 2011.

2) Cross-section standard deviation of Latin America real GDP per capita around USA (Sigma convergence) was calculated as

$$SD_t = \sqrt{\frac{\sum_{i}^{n} (GDPPER_{i,t} - GDPPER_{USA,t})^2}{n-1}}$$

To analyze more precisely the dynamics of LSA countries per capita real GDP around USA, we estimate following regression that well-known to β-convergence equation:

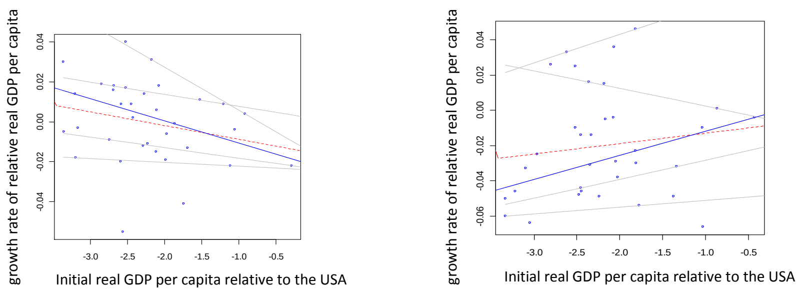
$$GRI_i = \alpha + \beta \ln(\frac{RI_i}{RI_{USA}}) + \varepsilon_i \qquad (1)$$

Where GRI_i is the average relative per capita real GDP growth rate for country i and RI is per capita real GDP. We estimated equation (1) for the past four decades (1970’s, 1980’s, 1990’s and 2000’s) separately and use two estimators namely OLS and quantile regression. As mentioned in economic growth literature, estimation of β-convergence equation using OLS ignore Galton's fallacy (Friedman, 1992; and Quah, 1993). Hence when we use the OLS for estimating equation (1), a negative estimated value for β may not indicate that economies in our sample are converging to the same long-run steady state. There is possible some countries are converging toward same balanced growth path and some others are diverging. But quantile regression (introduced by Koenker and Basset, 1978) able to estimate parameter β for each conditional quantile of dependent variable i.e. average relative per capita real GDP growth rates. Thus, as noted by Koenker (2000), it able to solve the Galton's fallacy and identify various convergence or divergence patterns in a sample of countries.

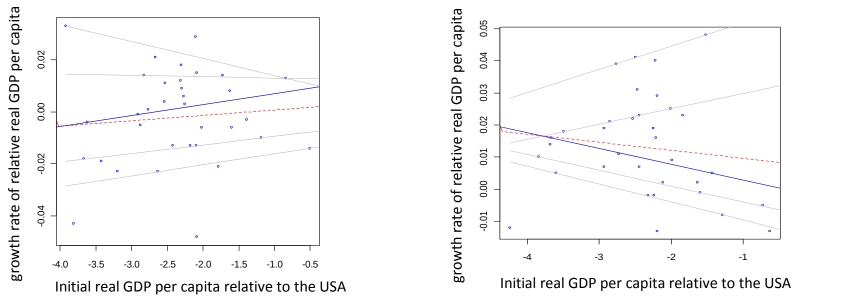
The results of OLS and quantile regression present in Figure 2. We plot the fitted values for OLS regression as red line. Fitted values for quantile 50% (median) show with blue line and fitted values for other quantiles i.e. 10%, 25%, 80%, and 95% with gray lines. As can be seen, convergence patterns differ among countries in any decades and among decades. We see a convergence toward USA for all quantiles in decades 70's. As we discussed in table 1, most of LSA countries experienced negative or low growth rate over decade 1980_s, hence we see divergence from USA for all quantiles except quantile 80%. In decade 1990_s, only the countries that exist in quantile 95% could lie in convergence path and other countries diverged from USA. Our results about convergence pattern among LSA countries using β-convergence and quantile regression confirm with sigma convergence evidence that was present in panel B of Figure 1. The results of quantile regression for the period 2000-2011 in panel D of Figure 2 show that the countries that exist in quantiles 10%, 25% and 50% could converge toward the USA but the countries that exist in quantiles 80% and 95% were diverged from the USA.

Fig. 2: Fitted Values for OLS and Quantile Regressions

Panel A: 1970_s	Panel B: 1980_s



Panel C: 1990_s | Panel D: 2000_s



1) Red line: Fitted values for OLS estimation
2) Blue line: Fitted values for 50% quantile (median)
3) Gray lines: Fitted values for 10%, 25%, 80%, and 95% quantiles

2.3 Methodology

As noted in section 1, in this paper we are going to test the convergence toward the USA for LSA countries using time series of the convergence hypotheses. The time series approach introduced by Carlino and Mills (1993) and developed by Bernard and Durlauf (1996), Evans and Karras (1996) and Li and Papell (1999). According to this approach, country i will be converged toward the USA (as the leader or benchmark country) if, and only if:

$$\lim_{n\to\infty}(RI_{i,t+n} - aRI_{USA,t+n} \,|\Phi_t) = 0 \qquad (2)$$

Where RI is logarithm the relative per capita real GDP and Φ_t is the information set at time t. i denotes country i. We can define three versions of the convergence hypothesis using equation (2). If $a = 1$ then it shows absolute convergence. In order to test this definition, researchers use unit root or stationary test without intercept and linear trend. If $a \neq 0$ and the series $(RI_{i,t} - RI_{USA,t})$ be level stationary, it is named conditional convergence or deterministic convergence. If $a \neq 0$ and the series $(RI_{i,t} - RI_{USA,t})$ be trend stationary, it is named stochastic convergence or catching up process. As noted by Li and Papell (1999, P: 268), stochastic convergence is weakest definition of convergence hypothesis under the time series framework. “This definition, however, is open to criticism because the presence of a time trend allows for permanent per capita output differences” (Li and Papell, 1999, P: 268).

As noted in section 1, we use the CBL stationarity test for testing the conditional and stochastic convergence. The CBL extended the Hadri (2000) test and allowing for two different types of multiple structural breaks, first, breaks in intercept (without linear trend) and second, breaks in intercept and slope of linear trend. The CBL stationary test is adopted in this study due to its advantages that noted in section 1. According to the CBL stationary test, the data generation process under the null of stationary is based on following model:

$$Rh_t = \alpha + \beta T + \sum_{k=1}^{m} \theta_k DU_{k,t} + \sum_{k}^{m} \rho_k DT_{k,t} + \varepsilon_t \tag{3}$$

In equation (3), α , T and m are intercept, linear trend and the optimal number of breaks respectively. The other factors that regressed are defined as the following:

$$DU_{k,t} = \begin{cases} 1 & \text{if} \quad t > TB_k \\ 0 & \text{otherwise} \end{cases} \tag{4}$$

$$DT_{k,t} = \begin{cases} t - TB_k & \text{if} \quad t > TB_k \\ 0 & \text{otherwise} \end{cases} \tag{5}$$

The test statistic is computed as Kwiatkowski et al (1992) test with multiple breaks:

$$LM(\lambda) = \hat{\omega} T^{-2} \sum_{t=1}^{T} \hat{S}_t^{\,2} \tag{6}$$

Where $\hat{S}_t$ is the partial sum of the estimated OLS residuals from equation (3) $\hat{\omega}$ Denotes a heteroscedasticity and autocorrelation consistent estimate of the long –run variance of ε_t . λ is the location of the breaks relative to the entire time period (T). The test statistic is dependent on the λ , hence that is important that we identify the location and the number of breaks correctly. The CBL recommend using the Bai and Perron (1998) procedure that is based upon the global minimization of the sum of squared residuals (SSR) as follows:

$$(\hat{TB}_1,...,\hat{TB}_m) = \arg\min_{(\hat{TB}_1,...,\hat{TB}_m)} SSR(\hat{TB}_1,...,\hat{TB}_m) \tag{7}$$

The optimal number of breaks is selected by CBL criterion of Liu, Wu, & Zidek (1997). In this paper, the finite sample critical values are computed by Monte Carlo simulations using 20000 replications.

As noted by Tomljanovich & Vogelsang (2002), Cunado & Gracia (2006), for the deterministic and the stochastic convergence hypothesizes; the level stationary and the trend stationary are necessary conditions. In order to investigate the sufficient condition for the conditional convergence and catching up hypothesis, we follow Tomljanovich & Vogelsang (2002), Cunado & Gracia (2006), and Carrion-i-Silvestre and German-Soto (2009) and estimate the following equations (8) and (9) for countries that the null of level stationary and trend stationary is not rejected for them.

$$RI_t = \sum_{k=1}^{m+1} \theta_k DU_{k,t} + \varepsilon_t \tag{8}$$

$$RI_t = \sum_{k=1}^{m+1} \theta_k DU_{k,t} + \sum_{k=1}^{m+1} \rho_k DT_{k,t} + \varepsilon_t \tag{9}$$

In the Equations (8) and (9), RI is logarithm the relative per capita real GDP, t and m are time and optimal number of breaks respectively. The factors that regressed are defined as the following:

$$DU_{k,t} = \begin{cases} 1 & \text{if} \quad TB_{k-1} < t < TB_k \\ 0 & \text{otherwise} \end{cases} \tag{10}$$

$$DT_{k,t} = \begin{cases} t - TB_{k-1} & \text{if} \quad TB_{k-1} < t < TB_k \\ 0 & \text{otherwise} \end{cases} \tag{11}$$

Whereas the real GDP per capita of all the LSA countries were less than the USA real GDP per capita in 1969, hence for deterministic convergence, it is necessary that the intercept in equation (8) after k^{th} break point be greater than intercept after $(k-1)^{th}$ break point. In other words, it is necessary that for the deterministic convergence, the intercept in equation (8) that represents the steady state relative per capita GDP, increase after any break.

According to the Carrion-i-Silvestre and German-Soto (2009, P: 318), we can say that there exist evidence of catching up process or stochastic convergence when in equation (9) $\theta_k < 0$ and $\rho_k > 0$ or when $\theta_k > 0$ and $\rho_k < 0$ and all coefficients are significant at least at the 10% level of significance. If both parameters of each regime have the same sign and are significant at the 10% level of significance, we conclude the divergence has occurred. If both parameters (θ_k and ρ_k) are insignificant, it suggests that catching up process has occurred. If catching up process occurred but only one of the parameters is significant, we conclude that weak catching up process has occurred and when both of them is same sign but only one of the parameters is significant, the weak divergence has occurred.

3. Empirical Results

In order to test the convergence hypothesis toward the USA for LSA countries, first we apply the unit root tests and for this end, we use five univariate unit root tests namely, ADF, DF-GLS, NG-Perron, PP, and KPSS that do not allow for structural breaks and also use the CBL stationary. Whereas in this paper, we want to test two version of convergence hypothesis i.e. deterministic or conditional convergence and stochastic convergence or catching up hypothesis, we run two versions of all mentioned unit root tests i.e. testing the unit root test when only intercept allows and testing the unit root test when intercept and linear trend allow. The results of univariate unit root tests are presented in Table 2. As we can see from Table 2, all univariate unit root tests specially the unit root tests with unit root as null hypothesis could not reject the unit root hypothesis for most of countries. For example, according to ADF unit root test, we could test the sufficient condition for deterministic convergence only for two countries namely, St Kitts and Nevis and Uruguay. According to Ng-Perron unit root test, the unit root hypothesis is not rejected for any countries for both versions. Hence we could not test the sufficient condition for any countries.

This result is consistent with that of existing literature and is due to the low power of these univariate unit root tests in finite sample and when the relative per capita real GDP contain a broken linear trend or broken intercept. In this situation, univariate unit tests that allows for structural breaks are found to be of great help provided that they allow for structural breaks in intercept and slope of linear trend function. Hence we apply two versions of the CBL stationary test that allow for structural breaks in intercept and structural breaks in intercept and slope of linear trend.

Table2: Univariate Unit Root Test Results without Structural Breaks

Countries	With Constant					With constant and trend				
	ADF	DF-GLS	Ng-Perron	PP	KPSS	ADF	DF-GLS	Ng-Perron	PP	KPSS
Antigua and Barbuda	-2.14(0)	-0.26(1)	0.415[2]	-1.928[2]	0.712**[5]	-0.293(0)	-1.125(1)	-1.444[2]	-0.592[2]	0.102[4]
Argentina	-1.814(1)	-1.318(1)	-1.96[2]	-1.553[2]	0.55**[5]	-0.095(0)	-1.406(1)	-2.503[1]	-0.399[1]	0.188**[5]
Bahamas	-2.541(0)	-0.755(0)	-1.32[2]	-2.62*[2]	0.552**[4]	-2.606(0)	-2.018(0)	-7.633[2]	-2.83[2]	0.061[4]
Barbados	-0.65(0)	-0.539(0)	-0.744[4]	-0.57[4]	0.775***[5]	-3.241*(3)	-2.78(0)	-10.63[1]	-3.82**[1]	0.126*[3]
Belize	-1.666(1)	-0.758(1)	-0.325[1]	-1.61[1]	0.758***[5]	-4.213***(2)	-4.111***(2)	-10.46[1]	-2.507[1]	0.052[3]
Bolivia	-1.465(1)	-0.969(1)	-0.706[4]	-1.412[4]	0.659**[5]	-0.959(1)	-1.418(1)	-2.681[4]	-0.585[4]	0.168**[5]
Brazil	-1.641(0)	-1.001(0)	-3.365[4]	-1.948[4]	0.402*[5]	-2.894(0)	-1.559(0)	-3.35[3]	-2.875[3]	0.104[5]
Chile	-0.163(2)	-0.382(1)	-0.293[3]	-0.08[3]	0.635**[5]	-2.626(1)	-1.889(1)	-2.643[1]	-2.031[1]	0.152**[5]
Colombia	-1.67(1)	-1.398(1)	-4.917[3]	-1.762[3]	0.128[4]	-1.424(1)	-1.756(1)	-6.053[3]	-1.713[3]	0.142*[5]
Costa Rica	-1.493(1)	-1.508(1)	-3.929[4]	-1.227[4]	0.224[5]	-0.995(1)	-1.452(1)	-3.273[4]	-0.892[4]	0.182**[5]
Cuba	-1.906(1)	-1.898*(1)	-4.259[4]	-1.456[4]	0.188[5]	-1.855(1)	-1.936(1)	-4.41[4]	-1.445[4]	0.199**[5]
Dominica	-1.341(0)	-0.802(0)	-0.978[2]	-1.299[2]	0.616**[5]	-1.661(0)	-1.744(0)	-5.609[0]	-1.661[0]	0.127*[5]
Dominican Republic	-0.155(1)	0.837(0)	1.665[3]	-1.35[3]	0.482**[5]	-1.25(0)	-1.573(1)	-4.87[3]	-1.809[3]	0.118[5]
Ecuador	-0.834(0)	-0.847(0)	-2.453[3]	-1.095[3]	0.581**[5]	-1.692(0)	-1.314(0)	-4.594[3]	-2.041[3]	0.093[5]
El Salvador	-2.046(1)	-1.33(1)	-1.054[4]	-1.65[4]	0.493**[5]	-1.51(1)	-1.657(1)	-2.2[4]	-0.885[4]	0.119[5]
Grenada	-1.991(0)	-0.577(0)	-0.14[2]	-1.978[2]	0.667**[5]	-0.657(0)	-0.835(0)	-1.456[3]	-0.594[3]	0.188**[5]
Guatemala	-1.571(1)	-1.292(1)	-1.338[4]	-1.015[4]	0.631**[5]	-1.536(1)	-1.81(1)	-4.999[4]	-1.583[4]	0.171**[5]
Guyana	-2.135(1)	-1.48(1)	-1.482[1]	-1.61[1]	0.46*[5]	-1.445(1)	-1.661(1)	-1.244[0]	-0.427[0]	0.097[5]
Haiti	-0.341(0)	0.709(0)	0.947[0]	-0.341[0]	0.79***[5]	-1.834(0)	-1.576(0)	-3.896[1]	-1.818[1]	0.213**[5]
Honduras	-0.483(0)	-0.525(1)	-0.566[4]	-0.735[4]	0.707**[5]	-1.532(0)	-1.297(0)	-5.522[4]	-2.005[4]	0.094[5]
Jamaica and Dependencies	-2.106(1)	-1.03(1)	-0.697[3]	-1.298[3]	0.613**[5]	-1.925(1)	-1.994(1)	-6.624[3]	-1.796[3]	0.125*[4]

Countries	With Constant					With constant and trend				
	ADF	**DF-GLS**	**Ng-Perron**	**PP**	**KPSS**	**ADF**	**DF-GLS**	**Ng-Perron**	**PP**	**KPSS**
Mexico	-1.666(1)	-1.705*(1)	-3.805[2]	-1.359[2]	0.533**[5]	-2.388(1)	-2.214(1)	-6.23[2]	-2.279[2]	0.16**[5]
Nicaragua	-1.648(0)	-0.452(1)	0.242[2]	-1.556[2]	0.721**[5]	-0.023(0)	-1.021(1)	-1.376[1]	-0.26[1]	0.177**[4]
Panama	-1.582(1)	-1.596(1)	-3.154[2]	-0.885[2]	0.229[5]	-0.95(1)	-1.582(1)	-1.823[2]	-0.153[2]	0.123*[4]
Paraguay	-1.739(1)	-1.632*(1)	-3.863[4]	-1.55[4]	0.344[5]	-2.134(1)	-1.867(1)	-4.166[4]	-1.988[4]	0.16**[5]
Peru	-1.733(1)	-1.325(1)	-1.404[1]	-1.319[1]	0.557**[5]	-0.59(1)	-1.288(1)	-0.623[4]	0.295[4]	0.157**[5]
Puerto Rico	-2.092(0)	-0.764(0)	-1.037[3]	-2.046[3]	0.685**[5]	-1.124(0)	-2.044(2)	-6.948[3]	-1.767[3]	0.09[4]
St Kitts and Nevis	-3.468**(0)	-0.045(1)	0.648[4]	-3.28**[4]	0.77***[5]	0.088(0)	-0.682(1)	1.755[8]	0.725[8]	0.101[5]
St Lucia	-1.098(0)	-0.951(0)	-2.659[3]	-1.259[3]	0.502**[5]	-1.587(0)	-1.582(0)	-6.06[3]	-1.828[3]	0.172**[5]
St Vincent and the Grenadines	-0.622(0)	0.092(0)	0.959[6]	-0.486[6]	0.766***[5]	-2.418(0)	-2.448(0)	-8.559[5]	-2.346[5]	0.145*[5]
Suriname	-1.256(0)	-0.867(0)	-1.644[3]	-1.351[3]	0.577**[5]	-0.722(0)	-1.007(0)	-4.069[3]	-1.066[3]	0.176**[5]
Trinidad and Tobago	-1.309(1)	-1.345(1)	-3.076[4]	-1.052[4]	0.17[5]	-1.072(1)	-1.357(1)	-2.466[4]	-0.801[4]	0.15**[5]
Uruguay	-3.228**(1)	-2.873***(1)	-5.559[1]	-1.52[1]	0.156[4]	-2.916(1)	-3.169*(1)	-2.557[0]	-0.482[0]	0.108[4]
Venezuela	-1.375(0)	-0.242(0)	0.084[1]	-1.363[1]	0.744***[5]	-0.909(0)	-1.204(0)	-3.625[0]	-0.909[0]	0.146*[5]

***, ** and * indicate the null hypothesis is rejected at the 1%, 5% and 10% levels, respectively. The number in brackets indicates the lag order selected based on Schwarz information criterion. The number in the parenthesis indicates the truncation for the Bartlett Kernel, as suggested by the Newey-West test (1987).

The results of CBL stationary test that allows for break in intercept (without linear trend) are provided in table 3. As see, we could reject the null of stationary only for 11 countries namely Argentina, Brazil, Colombia, Cuba, Guyana, Haiti, Nicaragua, Paraguay, St Kitts and Nevis, Trinidad and Tobago, and Venezuela. For other 23 LSA countries the null of level stationary with multiple structural breaks is not rejected and thus we able to test the sufficient condition for them.

The numbers of breaks in table 3 show, relative per capita real GDP of all LSA countries experienced 130 structural breaks in their steady state level (intercept) over the period 1969-2011. The results show that only Ecuador experienced 7 breaks in the intercept and only one country namely Puerto Rico experienced one break in the intercept. Two countries (i.e. Honduras and Paraguay) experienced 6 breaks, 6 countries (namely Belize, Brazil, Dominica, Haiti, Trinidad,Tobago, & Venezuela) experience 5 breaks, 12 countries (namely Antigua and Barbuda, Argentina, Bahamas, Bolivia, Chile, Colombia, Dominican Republic, El Salvador, Jamaica and Dependencies, Nicaragua, St Kitts and Nevis, and Uruguay) experience 4 breaks, 8 countries (namely Barbados, Cuba, Guatemala, Guyana, Mexico, Peru, St Vincent and the Grenadines, and Suriname) experienced 3 breaks, and 4 countries (namely Costa Rica, Grenada, Panama, and St Lucia) experienced 2 breaks in the intercept. Also, from 130 structural breaks that occurred over the 1969-2011 period, respectively, 26, 44, 31, and 29 break points occurred over decades 1970_s, 1980_s, 1990_s, and 2000_s.

Whereas the stationary hypothesis is rejected for 11 countries, hence we able to decide about convergence process after 82 break points and for other break points we cannot say anything.

Analyzing of sufficient condition show that from 82 breaks in the intercept, 43 cases (52%) increased the relative per capita GDP level and were caused to conditional convergence and 39 cases (48%) decreased the relative per capita GDP level and were caused to divergence from the USA.

From 82 break points that occurred over the 1969-2011 period, 16, 27, 19, and 20 break points occurred in $1970_{s,}$ $1980_{s,}$ $1990_{s,}$ and 2000_{s} respectively. From 16 break points in 1970_{s}, 11 cases result in convergence and 5 cases results in divergence. From 27 break points in 1980_{s}, 7 cases result in convergence and 20 cases result in divergence. From 19 break points in 1990_{s}, respectively 9 and 10 cases results in convergence and divergence. Finally from 20 break points in 2000_{s}, 16 cases result in convergence and other result in divergence from the USA. As see, our results using time series approach for conditional convergence is consistent with β -convergence and sigma convergence results that were provided in previous section.

Also, our results show that three countries namely Grenada, Puerto Rico, and St Vincent and the Grenadines experienced conditional convergence toward the USA after any structural breaks. In fact, after any structural break, their relative per capita real GDP increased and their steady state level shifted upward.

In contrast, Barbados is the only country that lied in divergence path after any breaks and could not increase their per capita real GDP level over the period 1969-2011. 8 countries namely Antigua and Barbuda, Belize, Chile, Dominica, Dominican Republic, Grenada, Puerto Rico, and St Vincent and the Grenadines experienced convergence process more than divergence process in their per capita real GDP growth path over the period 1969-2011 and in contrast, Other countries experienced divergence process more than convergence process in their per capita real GDP growth path over the period 1969-2011.

Table 3: CBL Stationary Test with Breaks in Intercept and Conditional Convergence Results

Countries	uni_KPSS	90	95	99	first	second	third	4th	5th	6th	7th
Antigua and Barbuda	0.079	0.096	0.121	0.182	1974(↑)	1979(↑)	1985(↑)	2005(↑)			
Argentina	0.0699*	0.069	0.083	0.116	1977	1984	1999	2006			
Bahamas	0.045	0.074	0.088	0.119	1973(↓)	1978(↑)	1991(↓)	2005(↓)			
Barbados	0.031	0.074	0.086	0.112	1982(↓)	1991(↓)	2000(↓)				
Belize	0.038	0.056	0.066	0.087	1973(↑)	1979(↑)	1983(↓)	1989(↑)	2001(↑)		
Bolivia	0.051	0.073	0.086	0.115	1980(↓)	1984(↓)	1998(↓)	2007(↑)			

Countries	uni_KPSS	90	95	99	first	second	third	4th	5th	6th	7th
Brazil	0.057*	0.053	0.059	0.075	1972	1982	1989	1997	2007		
Chile	0.045	0.090	0.109	0.156	1972(↓)	1990(↑)	1994(↑)	2006(↑)			
Colombia	0.0811*	0.070	0.084	0.115	1973	1983	1998	2006			
Costa Rica	0.106	0.136	0.169	0.254	1981(↓)	2005(↑)					
Cuba	0.1068**	0.077	0.089	0.116	1980	1991	2005				
Dominica	0.055	0.060	0.070	0.091	1980(↑)	1986(↑)	1990(↑)	2001(↓)	2007(↑)		
Dominican Republic	0.055	0.068	0.079	0.100	1972(↑)	1984(↓)	1996(↑)	2006(↑)			
Ecuador	0.034	0.040	0.046	0.058	1973(↑)	1982(↓)	1986(↓)	1994(↓)	1998(↓)	2003(↑)	2007(↑)
El Salvador	0.067	0.070	0.082	0.109	1979(↓)	1983(↓)	1992(↑)	2006(↑)			
Grenada	0.118	0.140	0.183	0.276	1978(↑)	1986(↑)					
Guatemala	0.087	0.142	0.180	0.266	1973(↑)	1982(↓)	1986(↓)				
Guyana	0.1146*	0.104	0.126	0.176	1982	1987	1992				
Haiti	0.0968**	0.067	0.082	0.115	1983	1987	1991	1997	2002		
Honduras	0.041	0.043	0.048	0.059	1973(↑)	1982(↓)	1986(↓)	1993(↓)	1998(↓)	2006(↑)	
Jamaica and Dependencies	0.062	0.069	0.082	0.110	1975(↓)	1979(↓)	1990(↑)	1997(↓)			
Mexico	0.072	0.083	0.101	0.141	1978(↑)	1985(↓)	1994(↓)				
Nicaragua	0.1088*	0.099	0.122	0.182	1978	1983	1987	1991			
Panama	0.123	0.126	0.152	0.211	1986(↓)	2006(↑)					
Paraguay	0.0608**	0.051	0.060	0.081	1974	1978	1983	1995	1999	2007	
Peru	0.100	0.105	0.128	0.178	1982(↓)	1988(↓)	2007(↑)				
Puerto Rico	0.124	0.152	0.185	0.257	1990(↑)						
St Kitts and Nevis	0.1423**	0.091	0.113	0.164	1973	1978	1986	1992			
St Lucia	0.072	0.120	0.147	0.208	1989(↑)	1996(↓)					
St Vincent and the Grenadines	0.090	0.094	0.116	0.169	1987(↑)	1997(↑)	2005(↑)				
Suriname	0.053	0.117	0.143	0.204	1982(↓)	1986(↓)	2007(↑)				
Trinidad and Tobago	0.0938**	0.062	0.074	0.104	1977	1983	1987	2001	2005		
Uruguay	0.062	0.067	0.079	0.105	1982(↓)	1991(↑)	2000(↓)	2007(↑)			
Venezuela	0.0641**	0.051	0.058	0.073	1978	1982	1988	1998	2005		

Notes: ↑ denotes break increased the GDP per capita level (conditional convergence) and ↓ denotes break decreased the GDP per capita level (divergence). For countries that the null hypothesis of stationary is rejected, we could not decide about their convergence process. The finite sample critical values are computed by Monte Carlo simulation using 20000 replications. *, **, and *** denote the null hypothesis is rejected at the 10%, 5%, and 1%.maximum number of breaks fixed at seven.

We present the results for catching up hypothesis in the Table 4. The results of CBL stationary test with multiple structural breaks in intercept and slope of linear trend function show that the null of stationary hypothesis is rejected for 14 countries namely Bahamas, Barbados, Brazil, Chile, Costa Rica, Dominican Republic, Ecuador, El Salvador, Jamaica and Dependencies, Nicaragua, Paraguay, Puerto Rico, Suriname, and Trinidad and Tobago at least at 10%. Hence we have to test the sufficient conditions only for 20 out of 34 countries.

Dispersion of number of breaks among countries show that two countries namely El Salvador and Suriname experienced 2 breaks in their catching up process. Four countries namely Costa Rica, Honduras, Paraguay, and Peru experienced 7 breaks, 12 countries namely Belize, Bolivia, Brazil, Chile, Colombia, Cuba, Dominican Republic, Ecuador, Guyana, Nicaragua, Trinidad and Tobago, and Venezuela experienced 6 breaks, 9 countries namely Antigua and Barbuda, Bahamas, Barbados, Guatemala, Jamaica and Dependencies, Panama, Puerto Rico, St Kitts and Nevis, and Uruguay experienced 5 breaks, 6 countries namely Argentina, Dominica, Haiti, Mexico, St Lucia, and St Vincent and the Grenadines experienced 4 breaks, and only Grenada experienced one break in catching up process toward the USA.

Number and date of break points show that total LSA countries relative per capita real GDP series experienced 188 breaks over the period 1969-2011 that respectively 47, 55, 51, and 35 break points occurred in 1970_s, 1980_s, 1990_s and 2000_s.

Whereas the stationary hypothesis was rejected for 14 countries, hence we have to test the sufficient condition only for 102 of 188 break points. The results of testing the sufficient condition show that all countries were diverged at least once from the USA over the period 1969-2011. Five countries namely Bolivia, Guyana, Honduras, Peru, and Venezuela experienced divergence process more than other countries and three countries namely Belize, Colombia, and Cuba experienced catching up process more than other countries over the period 1969-2011.

Other results show that from 102 break points, 53 cases result in catching up and other result in divergence from the USA. Also dispersion of break dates among four decades show that from 102 break points, 12, 14, 10, and 17 cases result in catching up toward the USA and 10, 16, 19, and 4 cases result in divergence in 1970_s, 1980_s, 1990_s and 2000_s respectively.

Table 4: CBL Stationary Test with Breaks in Intercept and Slop of Linear Trend and Catching up Results

Countries	uni_KPSS	90%	95%	99%	Pre-first	after first	after second↘	after 3th	after 4th	after 5th	after 6th	after 7th	after 8th
Antigua and Barbuda	0.016	0.040	0.049	0.070	(↗)	1979(↗)	1985 (↗)	1991 (↘)	2002 (↗)	2007 (↘)			
Argentina	0.022	0.040	0.049	0.068	(↘)	1979(↘)	1990 (↗)	1997 (↘)	2001 (↗)				
Bahamas	0.0519***	0.024	0.027	0.033									
Barbados	0.0288***	0.021	0.023	0.027									
Belize	0.018	0.019	0.020	0.024	(↗)	1973(↗)	1979 (↘)	1986 (↗)	1992 (↘)	1997 (↗)	2003 (↗)		
Bolivia	0.018	0.021	0.024	0.029	(↗)	1974(↘)	1982 (↘)	1986 (↘)	1990 (↘)	1998 (↘)	2005 (↗)		
Brazil	0.0445***	0.023	0.027	0.035									
Chile	0.0331***	0.023	0.025	0.031									
Colombia	0.018	0.024	0.028	0.036	(↗)	1975(↗)	1981 (↘)	1985 (↗)	1994 (↘)	1998 (↗)	2005 (↗)		
Costa Rica	0.0274***	0.018	0.020	0.024									
Cuba	0.016	0.041	0.050	0.073	(↗)	1979(↗)	1983 (↘)	1989 (↘)	1993 (↗)	2003 (↗)	2007 (↗)		
Dominica	0.027	0.037	0.044	0.059	(↗)	1978(↗)	1982 (↗)	1990 (↘)	2002 (↗)				
Dominican Republic	0.0229*	0.022	0.024	0.030									
Ecuador	0.0423***	0.019	0.021	0.024									
El Salvador	0.0474***	0.017	0.019	0.023									
Grenada	0.034	0.082	0.105	0.158	(↗)	1986(↗)	1992 (↗)	1998 (↘)					
Guatemala	0.026	0.030	0.034	0.045	(↗)	1973(↗)	1981 (↘)	1985 (↘)	1990 (↘)	2006 (↗)			
Guyana	0.017	0.021	0.023	0.029	(↘)	1974(↘)	1980 (↘)	1984 (↘)	1990 (↗)	1997 (↘)	2006 (↗)		
Haiti	0.033	0.040	0.048	0.067	(↘)	1979(↘)	1990 (↘)	1994(↘)	2003(↗)				

Countries	**uni_KPSS**	**90%**	**95%**	**99%**	**Pre-first**	**after first**	**after second↘**	**after 3th**	**after 4th**	**after 5th**	**after 6th**	**after 7th**	**after 8th**
Honduras	0.018	0.018	0.020	0.024	(↘)	1973(↗)	1979 (↘)	1985 (↘)	1989 (↗)	1993 (↘)	1998 (↘)	2006 (↗)	
Jamaica and Dependencies	0.0358***	0.024	0.026	0.031									
Mexico	0.034	0.037	0.042	0.053	(↗)	1976(↗)	1982(↘)	1987(↗)	1994(↗)				
Nicaragua	0.0268***	0.020	0.022	0.027									
Panama	0.020	0.030	0.034	0.044	(↗)	1976(↗)	1982 (↘)	1987 (↗)	1991 (↘)	2003 (↗)			
Paraguay	0.0607***	0.020	0.022	0.027									
Peru	0.015	0.018	0.020	0.024	(↘)	1973(↘)	1977 (↗)	1982 (↘)	1986 (↘)	1990 (↗)	1997 (↘)	2003 (↗)	
Puerto Rico	0.034***	0.020	0.022	0.025									
St Kitts and Nevis	0.024	0.040	0.049	0.070	(↗)	1979(↘)	1983 (↗)	1988 (↗)	1997 (↗)	2007 (↘)			
St Lucia	0.036	0.050	0.062	0.091	(↘)	1981(↗)	1989 (↗)	1993 (↘)	2000 (↗)				
St Vincent and the Grenadines	0.028	0.034	0.039	0.050	(↗)	1972(↘)	1976 (↗)	1993(↗)	2006 (↘)				
Suriname	0.0401***	0.017	0.018	0.022									
Trinidad and Tobago	0.0265*	0.027	0.032	0.042									
Uruguay	0.018	0.024	0.027	0.033	(↘)	1973(↗)	1980 (↘)	1984 (↗)	1997 (↘)	2003 (↗)			
Venezuela	0.020	0.027	0.032	0.043	(↘)	1976(↘)	1983 (↘)	1988 (↗)	1992 (↘)	2002 (↗)	2007 (↘)		

Notes: ↗ and ↘ denote the catching up and divergence process after any break respectively. For countries that the null hypothesis of stationary is rejected, we could not decide about their convergence process. The finite sample critical values are computed by Monte Carlo simulation using 20000 replications. *, **, and *** denote the null hypothesis is rejected at the 10%, 5%, and 1%.maximum number of breaks fixed at eight.

4. Conclusion

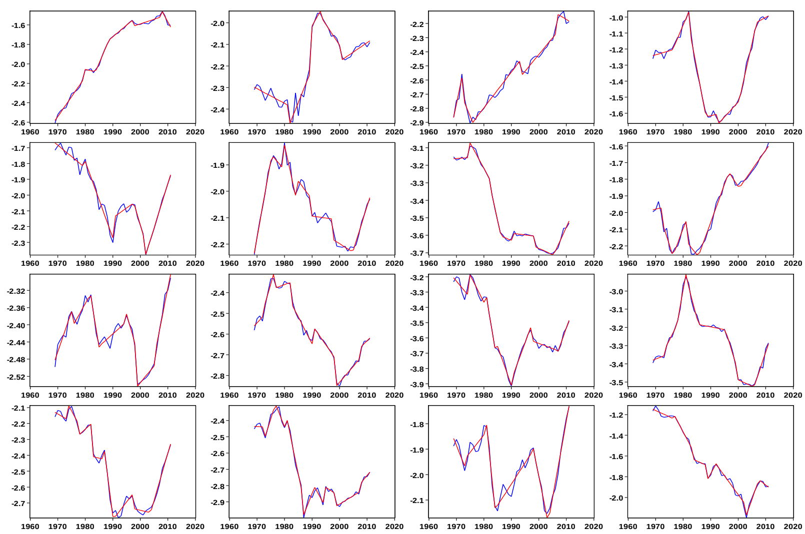
Present study tests one of the neoclassical growth theory outcomes namely convergence hypothesis for 34 Latin and South American (LSA) countries over the 1969-2011 period. To reach the end, it applies a novel stationary test that developed by Carrion-i- Silvestre *et.al.*(CBL) (2005). The CBL stationary test allow for flexible intercept and also flexible linear trend in per capita real GDP series. Hence it is very adequate for testing the convergence hypothesis and provides this possibility for researchers that analysis convergence behavior of per capita real GDP in several sub periods and investigates effect of different economic policies and other factors such as war on convergence process. In this paper, using two versions of CBL stationary test (break in intercept and break in intercept and slope of linear trend) we tested two versions of convergence hypothesis namely conditional or deterministic convergence and stochastic or catching up hypothesis. The results show that most of break points occurred in 1980_s and 1990_s that most of them result in divergence from the USA. But the structural breaks that occurred in 2000_s results in convergence and catching up toward USA. Dispersion of break dates and dynamics of per capita real GDP show that convergence process in LSA countries was affected by economic policies such as trade liberalization and external factors such as terms of trade shocks and war. Our results show that these factors had different effects on LSA countries. It seems based on the break points dates that trade liberalization has affected the catching up process more than deterministic convergence. Trade liberalization result in divergence from the USA in Bolivia but it help to catching up process of the Chile. Also it results in increasing the per capita real GDP in El Salvador and Trinidad and Tobago.

War in the El Salvador over the 1972-1979 results in continues decreasing in the its per capita real GDP.

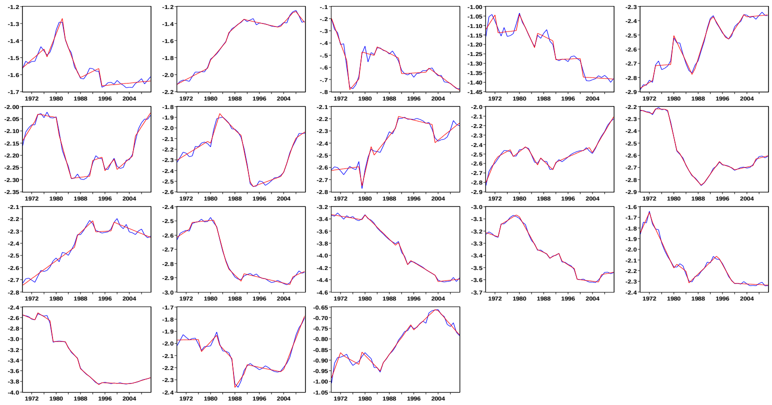
Terms of trade shocks due to volatility of primary goods prices such as sugar, copper, cotton, petroleum oil, coffee, bauxite, aluminum, and rice affected the convergence process in LSA countries. For example, sugar boom in the early of 1970_s results in Belize experienced a positive shock and could catch up toward the USA but ending its boom in second half of the 1970_s was caused Belize and St Kitts and Nevis experienced a negative shock. Coffee booms over the 1970_s were caused Guatemala and Honduras experienced a positive shocks in the 1973 but reducing of its priced over most years of 1980_s was caused they experienced a negative shocks in 1981 and 1985.

Fig. 3: Log of per capita Income Relative to the USA and Broken Trend, 1969–2011

Panel A: St Kitts and Nevis, St Lucia, St Vincent and the Grenadines, Trinidad and Tobago, Argentina, Brazil, Bolivia, Chile, Colombia, Ecuador, Guyana, Paraguay, Peru, Suriname, Uruguay, and Venezuela



Panel B: From left to right: Mexico, Antigua and Barbuda, Bahamas, Barbados, Belize, Costa Rica, Cuba, Dominica, Dominican Republic, El Salvador, Grenada, Guatemala, Haiti, Honduras, Jamaica and Dependencies, Nicaragua, Panama, and Puerto Rico



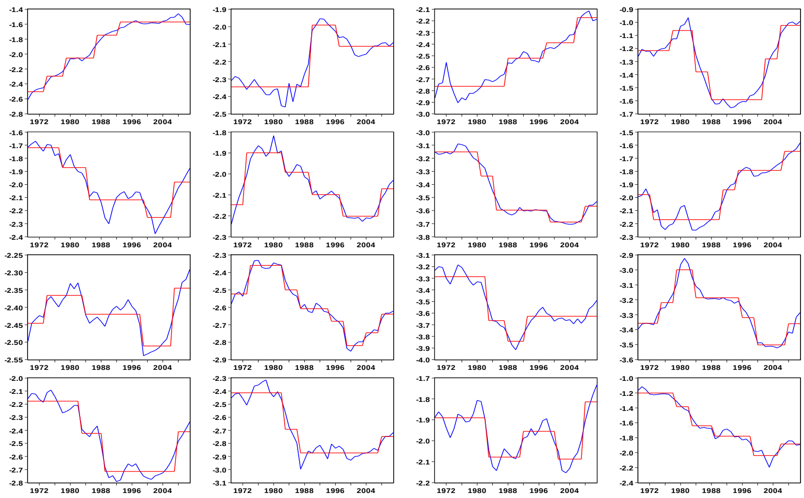
1) Blue line: actual series (ln (GDP per capita of country i/GDP per capita of USA).

2) Red line: estimated linear trend ($\hat{y}_t = \sum_{k=1}^{m+1} \hat{\theta}_k DU_{k,t} + \sum_{k=1}^{m+1} \hat{\rho}_k DT_{k,t}$). Where DU and DT are define such as equation (2)).

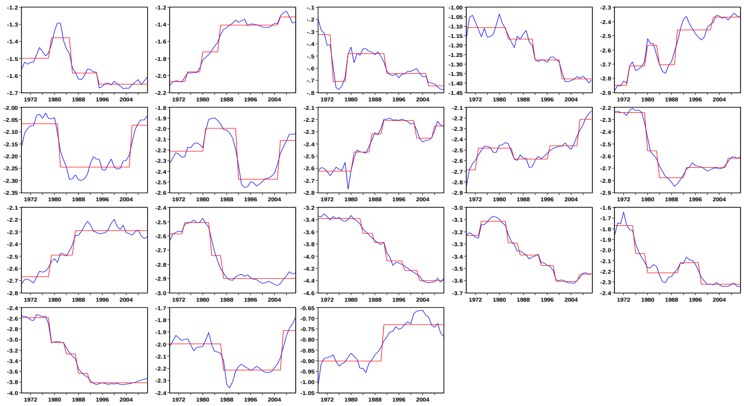
3) Left and bottom axis show the ln (GDP per capita of country i/GDP per capita of USA) and year respectively.

Fig. 4: Log of per capita Income Relative to the USA and Broken Intercept, 1969–2011

Panel A: St Kitts and Nevis, St Lucia, St Vincent and the Grenadines, Trinidad and Tobago, Argentina, Brazil, Bolivia, Chile, Colombia, Ecuador, Guyana, Paraguay, Peru, Suriname, Uruguay, and Venezuela



Panel B: From left to right: Mexico, Antigua and Barbuda, Bahamas, Barbados, Belize, Costa Rica, Cuba, Dominica, Dominican Republic, El Salvador, Grenada, Guatemala, Haiti, Honduras, Jamaica and Dependencies, Nicaragua, Panama, and Puerto Rico



1) Blue line: actual series (ln (GDP per capita of country i/GDP per capita of USA).
2) Red line: estimated linear trend ($\hat{y}_t = \sum_{k=1}^{m+1} \hat{\theta}_k DU_{k,t}$). Where DU and DT are define such as equation (2)).
3) Left and bottom axis show the ln (GDP per capita of country i/GDP per capita of USA) and year respectively.

References

Bai, J., & Perron, P. (1998). Estimating and Testing Linear Models with Multiple Structural Changes. *Econometrica*, *66* (1), 47-78.

Becker, R., Enders, W., & Lee, J. (2006). A Stationarity Test in the Presence of an Unknown Number of Smooth Breaks. *Journal of Time Series Analysis, 27*(3), 381-409.

Benabou, R. (1996). Inequality and Growth. *NBER Macroeconomics Annual*, *11*, Retrieved from http://www.nber.org/books/bern 96-1.

Bernard, A. B., & Durlauf, S. N. (1995). Convergence in International Output. *Journal of Applied Econometrics*, *10*(2), 97-108.

Bleaney, M., & Nishiyama, A. (2003). Convergence in Income Inequality: Differences between Advanced and Developing Countries. *Economics Bulletin*, *4*(22), 1-10.

Carlino, G. A., & Mills, L. O. (1993). Are US Regional Incomes Converging?: A Time Series Analysis. *Journal of Monetary Economics, 32*(2), 335-346.

Lluís Carrion-i-Silvestre, J., Barrio-Castro, D., & López-Bazo, E. (2005).

Breaking the Panels: an Application to the GDP Per Capita. *The Econometrics Journal*, *8*(2), 159-175.

Carrion-i-Silvestre, J. L., & German-Soto, V. (2009). Panel Data Stochastic Convergence Analysis of the Mexican Regions. *Empirical Economics*, *37*(2), 303-327.

Cuñado, J., & De Gracia, F. P. (2006). Real Convergence in Africa in the Second-Half of the 20th Century. *Journal of Economics and Business*, *58*(2), 153-167.

Dickey, D. A., & Fuller, W. A. (1979). Distribution of the Estimators for Autoregressive Time Series with a Unit Root. *Journal of the American Statistical Association*, *74*(366a), 427-431.

Elliott, G., Rothenberg, T. J., & Stock, J. H. (1992). Efficient Tests for an Autoregressive Unit Root. *Econometrica* , *64*(4), 813-836.

Evans, P., & Karras, G. (1996). Convergence Revisited. *Journal of Monetary Economics*, *37*(2), 249-265.

Ezcurra, R., & Pascual, P. (2005). Is there Convergence in Income Inequality Levels Among the European Regions? *Applied Economics Letters*, *12*(12), 763-767.

Friedman, M. (1992). Do Old Fallacies Ever Die? *Journal of Economic Literature*, *30*, 2129–2132.

Gomes, F. (2007). Convergence in Income Inequality: the Case of Brazilian Municipalities. *Economics Bulletin*, *15*(15), 1-9.

Hadri, K. (2000). Testing for Stationarity in Heterogeneous Panel Data. *The Econometrics Journal*, *3*(2), 148-161.

Holmes, M. J. (2005). Is Long-Run Output Convergence Associated with International Cooperation? Some New Evidence for Selected African Countries. *Journal of Economic Development*, *30*(2), 67.

Islam, N. (2003). What Have we Learnt from the Convergence Debate? *Journal of Economic Surveys*, *17*(3), 309-362.

Han Kim, E., & Singal, V. (2000). Stock Market Openings: Experience of Emerging Economies. *The Journal of Business*, *73*(1), 25-66.

Koenker, R., & Bassett Jr, G. (1978). Regression Quantiles. Econometrica: Journal of the Econometric Society. *Econometrica* , *46* (1), 33-50.

Koenker, R. (2000). Galton, Edgeworth, Frisch, and Prospects for Quantile Regression in Econometrics. *Journal of Econometrics, 95*(2), 347-374.

Kwiatkowski, D., Phillips, P. C., Schmidt, P., & Shin, Y. (1992). Testing the Null Hypothesis of Stationarity against the Alternative of a Unit Root: How Sure Are We that Economic Time Series have a Unit Root? *Journal of Econometrics, 54*(1), 159-178.

Li, Q., & Papell, D. (1999). Convergence of International Output Time Series Evidence for 16 OECD Countries. *International Review of Economics & Finance, 8*(3), 267-280.

Lin, P. C., & Huang, H. C. (2012). Convergence in Income Inequality? Evidence from Panel Unit Root Tests with Structural Breaks. *Empirical Economics, 43*(1), 153-174.

Liu, J., Wu, S., & Zidek, J. V. (1997). On Segmented Multivariate Regression. *Statistica Sinica, 7* (2), 497-525.

Ng, S., & Perron, P. (2001). Lag Length Selection and the Construction of Unit Root Tests with Good Size and Power. *Econometrica, 69*(6), 1519-1554.

Panizza, U. (2001). Convergence in Income Inequality. *Journal of Income Distribution, 10* (1), Retrieved from http://jid.journals.yorku.ca/index.php/jid/article/view/1276?v=1392752313000/_/jcr:system/jcr:version Storage/14/07/26/14072602-86aa-403b-a3d0-a179084b2869/1.5/jcr:frozen Node.

Phillips, P. C., & Perron, P. (1988). Testing for a Unit Root in Time Series Regression. *Biometrika, 75*(2), 335-346.

Quah, D. (1993). Galton's Fallacy and Tests of the Convergence Hypothesis. *The Scandinavian Journal of Economics, 95* (4), 427-443.

Ravallion, M. (2003). Inequality Convergence. *Economics Letters, 80*(3), 351-356.

Singh, A. (1999). Should Africa Promote Stock Market Capitalism? *Journal of International Development, 11*(3), 343.

Tomljanovich, M., & Vogelsang, T. J. (2002). Are US Regions Converging? Using New Econometric Methods to Examine Old Issues. *Empirical Economics, 27*(1), 49-62.